THE

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTAINING
THE PROCEEDINGS

JANUARY 1911

MEETINGS OF THE SOCIETY: NEW YORK, JANUARY 10
ST. LOUIS, JANUARY 14

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CONTENTS

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VOL. 33 JANUARY 1911 NUMBER 1

COMING MEETINGS

MEETING IN ST. LOUIS, JANUARY 14

The monthly meeting of the Society in St. Louis, which was called for Saturday evening, December 10, in the Engineers Club of St. Louis, has been postponed on account of the sudden death of William H. Bryan, Chairman of the Committee on Meetings of the Society in St. Louis. It will be held instead on January 14, when the paper on Modern Shoe Manufacture by M. B. Kaven and J. B. Hadaway, and that on Operating Conditions of Passenger Elevators by R. P. Bolton, will be considered.

JANUARY MEETING OF THE SOCIETY IN BOSTON

The January meeting of the Society in Boston will take the form of a dinner given by the three societies, the Boston Section of the American Institution of Electrical Engineers taking charge, and the Boston Society of Civil Engineers and The American Society of Mechanical Engineers coöperating. The occasion will be similar in its nature to the one given last year in honor of President Westinghouse and a number of prominent people are expected to be present and to address the gathering. The exact date has not yet been definitely announced.

MEETING IN NEW YORK, JANUARY 10

The monthly meeting for January will be held in the Engineering Societies Building on Tuesday evening, the tenth. The paper will

be on the Mechanical Handling of Freight, by S. B. Fowler, consulting engineer, Boston, Mass. This is the paper which was presented at the meeting in Boston in December and brought out an extended discussion. The question of terminal facilities and freight handling is so important a one in New York and the interests of railroads and shippers alike are so great that there should also be a thorough discussion at the New York meeting.

REPORTS OF MEETINGS

MEETING IN BOSTON, DECEMBER 16

A meeting of the Society in Boston was held on December 16, with the coöperation of the Boston Society of Civil Engineers and of the Boston Section of the American Institute of Electrical Engineers, the attendance being about 60. After the transaction of business Samuel B. Fowler, Mem.Am.Soc.M.E., presented his paper on the Mechanical Handling of Freight, and the various phases of the situation were discussed by D. B. Rushmore, Mem.Am.Soc.M.E., of the General Electric Company, Schenectady, N. Y.; C. W. E. Clarke, Assoc.Am.Soc.M.E., of the Stone and Webster Company, Boston; Ernest W. Day, Engineer for the Hood Rubber Company, Boston; F. W. Hodgden, Engineer of the Harbor and Land Commission; R. H. Rogers, of the Power and Mining Engineering Department, General Electric Company, Schenectady, N. Y.; R. E. Curtis, Mem.Am.Soc.M.E., Edison Electric Illuminating Company, of Boston; George H. Eaton, General Freight Agent of the Boston and Maine Railroad Company; and G. T. Sampson, Division Engineer of the New York, New Haven and Hartford Railroad Company. The whole subject aroused much interest on the part of those present.

MEETING IN SAN FRANCISCO, DECEMBER 16

As an outcome of plans made at the organization meeting of the members of the Society resident in San Francisco and vicinity on October 14, the first meeting for the discussion of professional topics was held in that city on December 16. Pacific Coast Practice in the Use of Crude Petroleum as Fuel was made the subject of a topical discussion, with the following brief papers: Present and Future Supply of Petroleum as Fuel on the Pacific Coast, by Arthur F. L. Bell, with the Associated Oil Company, San Francisco; Relative

Heating Value of Light Oil as Compared with Heavy Oil, by Prof. J. N. LeConte, Mem.Am.Soc.M.E., of the University of California, Berkeley; Comparison of Evaporative Value of Oil and Coal, by C. F. Wieland, Mem.Am.Soc.M.E., Consulting Engineer, San Francisco; Furnace Arrangements for Using Oil as Fuel under Boilers, including the Subject of Air Requisite for Proper Combustion, by C. R. Weymouth, Mem.Am.Soc.M.E., Mechanical Engineer in charge of the Engineering Department of Chas. C. Moore and Company, San Francisco; Practice as to Size of Stacks with Oil Fuel, K. G. Dunn, Assoc.Am.Soc.M.E., Vice-President of Hunt, Mirk and Company, Inc., San Francisco; Marine Use of Fuel Oil, by J. H. Hopps, Mem. Am.Soc.M.E., Consulting Engineer, San Francisco; Locomotive Practice in the Use of Fuel Oil, by Howard Stillman, Mem.Am.Soc. M.E., Mechanical Engineer and Engineer of Tests with the Southern Pacific Company, San Francisco; Atomization of Oil Fuel, including the subject of When and Where the Use of Compressed Air is Justified or Required, by A. M. Hunt, Mem.Am.Soc.M.E., Consulting Engineer, San Francisco; Present Status of the Manufacture of Producer Gas from Crude Oil, by E. C. Jones, Chief Engineer of the Gas Department, California Gas and Electric Corporation and San Francisco Gas and Electric Company, San Francisco.

After the reading of these papers, the meeting was thrown open and a very general discussion of the subject followed.

STUDENT BRANCHES

At the regular meeting of the Columbia Student Branch on December 2, F. B. Whittemore delivered a lecture on the Daimler Valveless Gas Engine.

Prof. H. E. Hibbard, Mem.Am.Soc.M.E., gave an account of the November meeting of the Society in St. Louis, at the meeting of the Missouri University Student Branch on November 22.

The Pennsylvania State College Student Branch held a meeting on November 17 at which a paper on the Utilization of Blast Furnace Waste Products was read by T. C. McConnell (1911), which was chiefly concerned with the uses of furnace gas as a fuel.

On December 17 the Polytechnic Institute Student Branch enjoyed an address by S. B. Redfield, Mem.Am.Soc.M.E., on Compressed Air. At the January meeting F. R. Low, Mem.Am.Soc.M.E., will address the members.

The Purdue Student Branch was addressed at its meeting of November 30, by C. Luhn, who spoke upon the New Cincinnati Water

Works. Prof. A. W. Cole, Mem.Am.Soc.M.E., was the speaker on December 14 and, with the topic of the Development of Steam Navigation, gave a brief historical sketch of the progress of the art since the time of the early Egyptians.

A new student branch has been formed at Rensselaer Polytechnic Institute with 18 members. At a business meeting on November 9 Prof. A. M. Greene, Jr., was elected Honorary Chairman and Harrison Weaver Secretary. At the conclusion of the business Professor Greene delivered an address on Steam Pumping Machinery which was illustrated with lantern slides.

J. B. Bubb, president of the Stanford Mechanical Engineering Society, presented a paper at the November 16 meeting on The Saw-Tooth Skylight.

On December 2 the Stevens Engineering Society considered the subject of Locomotives, with a paper by George W. Armstrong (1911), on the Mallet Compound Locomotive, illustrated by a reflectoscope. This was very fully discussed by others who were present.

The University of Wisconsin Student Branch held a meeting on December 8, at which J. Langwill gave a talk upon Special Drilling Machinery and E. Week spoke about the Cyanide Process of Extracting Gold. Prof. Kinne followed with an illustrated address upon Bridge Deflection with special attention to the work done along this line under the direction of the Dean of the College of Engineering, with the purpose of determining the effect of impact.

The Yale Mechanical Engineers Club entertained at its meeting on December 6, J. W. Lieb, Jr., of the New York Edison Company, Mem.Am.Soc.M.E., who gave an illustrated lecture on the different considerations in Power Plant Design with specific examples of several modern high-efficiency plants.

At a meeting of the University of Cincinnati Student Branch on November 18, J. D. Lyon of the Westinghouse Company presented a paper on Gas Engines and Producers, supplementing his remarks with lantern slides.

The University of Maine Student Branch has elected the following officers for the current year: A. H. Blaisdell, president; W. B. Emerson, secretary; C. E. Sullivan, vice-president; G. B. Chapman, treasurer. At a meeting on December 8, a paper on Rail-bond Testing for Electric Railways was presented by A. T. Childs, Assoc.A.I.E.E. The paper was well illustrated with lantern slides and was an excellent example of the use of automatic apparatus for the rapid collection of engineering data.

JOHN FRITZ MEDAL AWARD

The John Fritz Medal, established by the professional associates and friends of John Fritz, Hon. Mem.Am.Soc.M.E., of Bethlehem, Pa., in perpetuation of the memory of his achievements in industrial progress, and which is annually awarded by a Board made up of four representatives from each of the national engineering societies, the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, and The American Society of Mechanical Engineers, was formally bestowed, November 30, 1910, on Alfred Noble, Mem.Am.Soc.M.E., for notable achievements as a civil engineer. The Medal has been previously awarded to Lord Kelvin (1905) for his work in cable telegraphy and other scientific attainments; to George Westinghouse (1906) for the invention and development of the air brake; to Alexander Graham Bell (1907) for the invention and introduction of the telephone; to Thomas Alva Edison (1908) for the invention of the duplex and quadruplex telegraph, the phonograph, the development of a commercially practical incandescent lamp, and the development of a complete system of electric lighting; and to Charles T. Porter (1909) for his work in advancing the knowledge of steam engineering and in improvements in engineering construction.

The meeting, which was held at the house of the American Society of Civil Engineers, was called to order by Prof. Samuel Sheldon, Past-President Am.Soc.C.E., who stated briefly the significance of the medal and introduced Mr. Isham Randolph. Mr. Randolph spoke of the history of civil engineering and was followed by Dr. Rossiter W. Raymond, Secretary of the American Institute of Mining Engineers, who read a very happy biographical sketch of Mr. Noble's career from his early days on a Michigan farm down to the completion of the Pennsylvania Railroad Company. He was followed by Mr. Noble himself, than whom, to quote Dr. Raymond, few men have done more interesting and important work with greater aversion to talking about it. Mr. Noble said in substance that he was confident that the award of the Medal to him was made to the profession, of which he felt doubly honored to be ranked as the representative, rather than to himself as an individual. The civil engineer, he said, did not invent so much as prevent, and very little of his work was of any interest to the public.

At the close of the proceedings an informal reception was held in the main assembly room.

THE ANNUAL MEETING

The thirty-first Annual Meeting of The American Society of Mechanical Engineers was held in the Engineering Societies Building December 6–9, 1910, with an attendance of 633 members and 410 guests. This year the arrangement of the entertainment features of the program were in the hands of the newly appointed committee on Meetings of the Society in New York, Prof. Walter Rautenstrauch, Chairman. Through their action a committee on entertainment was formed, Edward Van Winkle, Chairman; a committee on excursions, Fred H. Colvin, Chairman; on acquaintanceship, R. V. Wright, Chairman; and a sub-committee on finance, Frederick A. Waldron, Chairman. The Bureau of Information was in charge of Professor Rautenstrauch. As a result of their efforts the visiting members and guests were afforded a thoroughly enjoyable time, with excursions of unusual interest. The reception given by Mr. and Mrs. Westinghouse on Thursday afternoon at the Hotel St. Regis contributed much to the pleasure of the convention and the usual evening receptions and the lecture by Dr. Georg Kerschensteiner were largely attended and brought out many expressions of commendation for the excellence of the arrangements.

OPENING SESSION, TUESDAY EVENING

As on the year previous, the president's reception on Tuesday evening was held in the rooms of the Society, which are well adapted to a gathering of this kind and are most attractive with their new furnishings and decorations. The evening opened with a session in the auditorium for the reading of the presidential address by the retiring President, George Westinghouse, who gave an account of the conception and development of the air brake which has constituted so large a part of the life-work of Mr. Westinghouse and has made possible the wonderful advance throughout the world resulting from modern transportation facilities. Following the address George A. Orrok for the Tellers of Election of Officers announced the names of the newly elected officers for the coming year, consisting of E. D. Meier, President; George M. Brill, E. M. Herr, H. H. Vaughan, Vice-Presidents;

D. F. Crawford, E. B. Katte, Stanley G. Flagg, Jr., Managers; and Prof. F. R. Hutton and Dr. Alex. C. Humphreys escorted the President-elect to the platform. Dr. Humphreys introduced President Meier with a few words of appreciation, to which he responded as follows:

I appreciate fully your kind confidence in bestowing on me the highest honor which can come to an American Engineer, and the grave responsibility its acceptance impose. But it is one of the glories of our noble profession that it gives great opportunities for service to our fellow men; and duty well done is its own best reward. This is strongly impressed on me by the simple, modest story your retiring president has just read to us, but which commemorates one of the most valuable services rendered to the whole civilized world in this age of engineering.

Remembering that his life work came after his youthful patriotism had rendered service in our old navy, I will remind you that while life lasts the old army boys are just as ready for duty as the tars; still we two are perhaps the last of the boys of the early sixties on whom you can confer this honor.

At the reception in the rooms the members and guests were received by the President and Mrs. Westinghouse, President-elect Meier, the Misses Meier, and Honorary Secretary Hutton and Mrs. Hutton, and the Secretary and music and refreshments added to the pleasure of the gathering.

WEDNESDAY MORNING SESSION

The first professional session of the meeting opened with the annual business meeting, President E. D. Meier in the chair. The Secretary read the report of the Tellers of Election to Membership which will be published in The Journal in the membership list of the Society. The list included 131 applicants for membership and 16 for advance in grade.

Worcester R. Warner, Past-President, reporting on the status of the Land and Building Fund, said that $88,920.03 had been received to date, leaving $85,765.03 to be raised. Mr. Warner supplemented his recital of the figures by an account of the efforts of the Committee in securing contributions. One firm which had previously contributed $1000 added an equal amount and a check for $500 from the president of the company. There were other instances of generous contributions and certain of them, though of considerably smaller amount, came from members who must have made a personal sacrifice. Many, however, have not contributed at all and still others have sent contributions which it is hoped will be supplemented by additional amounts.

The President then announced that the discovery had recently been made of a slight discrepancy in the charter under which the Society now acts, relating to the date of the Annual Meeting. The matter was referred to the Committee on Constitution and By-Laws, who had drawn up a certificate to be voted upon by ballot at the meeting and to be filed with the Secretary of State to the effect that it is intended to amend the present articles of incorporation and to make them conform with the Constitution. Jesse M. Smith, Past-President, read the certificate for the Committee and moved the adoption of the following resolution, which was seconded by W. F. M. Goss.

Whereas, The annual meeting of this Society has been for many years begun on the first Tuesday of December of each year; and

Whereas, The Constitution and By-Laws of the Society provide that the annual meeting shall begin on the first Tuesday of December in each year; and

Whereas, The Constitution and By-Laws provide for, and the election of officers has been, for many years past, by letter-ballot, cast prior to the beginning of the said annual meeting; and

Whereas, Upon the consolidation of this Society with the Mechanical Engineers' Library Association in 1907, the agreement of consolidation inadvertently provided that the annual election should be held on the second Tuesday of December in each year; and

Whereas, The Society has, in each year since that date, had its annual election by letter-ballot prior to the beginning of the said annual meeting, and has begun its annual meeting on the first Tuesday of December in each year, both in accordance with the Constitution and By-Laws of the Society; and it is the desire of the members that the annual meeting and annual election should be held in accordance with the said Constitution and By-Laws;

Now, therefore, be it resolved, That the time of beginning the annual meeting of this Society and the time and manner of holding the annual election of officers of the Society, be changed from the second Tuesday of December in each year, and be held at such time and in such manner as shall be provided in the Constitution and By-Laws of the Society.

After the resolution had been debated the Chairman appointed tellers of the vote for whom I. E. Moultrop announced that the resolution had been duly carried.

F. R. Hutton called attention to the need in this country of an adequate museum of engineering in which could be recorded the developments in engineering processes through models and apparatus, referring to the museum at Munich as an example of what could be accomplished. Several others followed emphasizing in their remarks the benefits to be derived from such museums and referring to similar

institutions in Europe, especially that at Munich. President E. D. Meier stated that over $4,000,000 had been received to erect a building for the exhibits contained in the Munich museum, and this in the small country of Bavaria. Attention was called to the efforts of the Smithsonian Institution in this direction. The Secretary stated that a room in the Engineering Societies Building was available for the beginning of such a museum.

Frank B. Gilbreth said, that as it was in order to make suggestions, he wished the Society would consider the advisability of a central bureau for the collection and preservation of data relating to scientific management. The work involved in the obtaining of original data seems an unnecessary expense and there should be a central bureau on the same plan as the government bureaus, where the results of investigations of others can be placed at the disposal of any who apply. C. E. Lucke of the Committee on Meetings said that his Committee had this particular question under consideration with plans relating to it and had recommended the appointment of a special committee to take up all of these relating subjects.

President E. D. Meier then referred to the address of the retiring President, George Westinghouse, given on the previous evening, in which was told the history of the great invention which had covered the entire world and made the name of Westinghouse known wherever an iron wheel rolls on a steel rail. Many a man considers himself an inventor when he brings out an idea. That is the first step and the next is to embody the idea in practice. Here difficulties arise such as Mr. Westinghouse referred to so easily, almost playfully, but which were actually very grave. If he had not been a man of powerful physique, he would not have been able to carry through his undertaking. The great inventor is not the one who has the first idea, as the public sometimes imagines, but one who works continuously through years of time for the perfection and application of the idea.

That is essentially the work of the engineer, and engineers can be proud of their contribution and of the fact that the whole progress of the world for the past fifty years has depended on the engineer in one way or another.

James M. Dodge, Past-President, followed with a motion of a vote of thanks to Mr. Westinghouse for his admirable and interesting address, which was unanimously carried by a rising vote.

The President then referred to the sad announcement which he had made on the previous evening, of the sudden death of William H. Bryan, Chairman of the Committee on Meetings of the Society in St.

Louis, who had risen to distinction in the engineering world through his own energy and ability. He was a personal friend with a wide acquaintance in the Society and had recently passed through a strenuous competitive examination for the appointment as Chief Engineer for the School Board of the City of Chicago, in which he had won and had secured the appointment.

L. R. Pomeroy of the Committee on Meetings of the Society, of which Mr. Bryan was also a member, offered the following resolution of condolence which was unanimously passed:

Resolved: That the members of The American Society of Mechanical Engineers assembled in Annual Meeting, having heard of the death of their fellow member, William H. Bryan, hereby express their sense of loss, appreciation of his services to the Society, and sympathy for his family.

It is further

Resolved: That a copy of this resolution be sent to his family.

Dr. John A. Brashear, Hon. Mem. Am. Soc. M. E., asked for suggestions from members of the Society regarding the Carnegie Technical Schools at Pittsburgh. The original intention of Mr. Carnegie was that the schools should be for the education of young men and young women who worked for their living, but that the institution had grown until it had taken high rank among technical institutions. There are now 2250 students with a waiting list of 2500. The schools have the support of trade unions which have recently contributed $35,000 towards the work.

Dr. Brashear said also that he had recently had a quarter of a million dollars placed in his hands by a citizen of Pittsburgh for the betterment of teaching and teachers in the public schools, and that when members of the Society went to Pittsburgh they should not think of its smoke alone, but of the efforts which were there being made to give workers a chance to earn a livelihood, to learn something and to be helped to positions of usefulness. One of the most beautiful things in this world is to help our fellow-man and only by this means will our work be well done.

The President asked that any who had suggestions to make regarding the place for the Spring Meeting should express their preference to members of the Committee on Meetings while in attendance at the Annual Meeting, and said that it would be agreeable to many if the next one could be held in the West, in view of the fact that the two last Spring Meetings had been in the East.

James M. Dodge, Past-President, Chairman of the Committee on Public Relations, said that whereas other committees of the Society

were working for the development of the Society itself, his committee had been appointed to look after the welfare of the profession at large. The work was but just beginning, the committee would gladly receive suggestions, and hoped to report substantial progress at the next meeting. One question under consideration was that of licensing engineers. It is not a simple problem, owing to the fact that there are both graduate engineers, so-called, and those who graduate from the school of experience.

Dr. Hutton followed with an invitation to visit the Museum of Safety in the Engineering Societies' Building, New York.

WEDNESDAY MORNING—PAPERS AND ADDRESSES

Following the business meeting the Honorary Secretary and the Secretary presented reports of the Joint Meeting of the Society with the Institution of Mechanical Engineers, held in Birmingham and London in July 1910. Dr. Hutton spoke as follows:

It may not be known to all the members of the Society that its Secretary and its Honorary Secretary were made appointees to the Joint Meeting of the American and British Societies of Mechanical Engineers in Birmingham, England, in July 1910. It seems therefore proper that something of an official report should be presented from these officers respecting that meeting. The Secretary has already reported in full upon the outward and visible elements of the meeting; there is left for the other officer to report at your request upon some of the inner and therefore perhaps broader significances of such a gathering

These would appear to be three-fold: first, to the members of the American Society participating; second, to the American Society as a whole; third, to the members of the British Society, and to the engineering profession as a whole.

To the members of the American Society participating, it is superfluous to speak of the personal pleasure of the trip. The ocean voyage was a yachting party of congenial friends with every appointment of luxury at their service. The sojourn in England was a house-party or week-end visit at a hospitable manor-house, whose hosts could not do too much to keep their guests busy and interested while the beauty and historic interest of the Midlands were a background for every excursion. But besides this, so intimate an association for twelve days means the changing of acquaintances into friends. The shared memories are bonds which will not easily

break; and the Society, made up in some cases of competitors in business who are now personal friends withal, is the stronger for the meeting of 1910.

The significance of the British Joint Meeting to the American Society as a whole is in the compliment paid to the visitors by the hosts in and around Birmingham and London in according to American engineering the standing of which such courtesies are the evidence. It dignifies a body of visitors when the scale of their reception is an indication that they are regarded as being "worth while." The reception by city officials on landing, the courtesies of the Lord Mayor of Birmingham, and the civic splendor of receptions at the Mansion House and in the City Gardens at Birmingham, do not pass to inconsequential outsiders. The whole profession is helped upward and forward by an atmosphere such as this.

In the third place the meeting should be memorable to the British Institution and to the profession at large, because of the topics selected for the American papers, the manner of their presentation and the quality of the discussion on them, and the representative character of the American deegates. The whole participation in the duties of the meeting by the official party was creditable and distinguished. Its influence will be favorably felt for many days.

It was the privilege of the Honorary Secretary in the regretted absence of the President of the Society to respond by request of his associates to the toast of The American Society of Mechanical Engineers at the great banquet in London with which the meeting closed. The sentiment was proposed by Sir William H. White, Past-President of the Institution. The substance of the speech of reply was forced upon a plane of dignity and earnestness by the proprieties of the occasion. Its leading features were:

That any event falls in the class of memorable or of commonplace happenings according as its inner or spiritual meaning is elevated or ordinary. The gathering at Runnymede was but a seditious uprising, unless we see in it the dawn of the philosophy that government is only stable when it secures the greatest good to the greatest number, the principle underlying the triumph of enlightened democracy in America and of constitutional government in England. The death of the Stuart Charles is but an insurrection and an assassination, unless there is seen behind it the lesson that no King "liveth unto himself." Here a tribute was paid to the self-sacrificing industry and devotion of King Edward VII for whom the land was then in mourning.

What were the significances of this Joint Meeting? Certainly threefold. There was first the fact that visitors from the United States were guests of the mother-country. Why does the American regard Old England as his home-land, even if he were not of English descent? It is more than the common language which underlies this; for many Americans have the languages of Europe as their own and the open doors to the literature of the Continent. The reasons seem deeper in philosophy and sentiment. To use a figure to bring out the thought, the civilizations of the world may be viewed as structures standing like pyramids on a plain. Research below the visible phenomena will show that the existing civilization has beneath it the customs of the people; below the customs and laws of the people are the conduct and examples of the individual units who make up the people. The source and origin of this behavior are the ideals and inspirations in the soul of the man, having as a rule their basis in his concept of his relation to a personal God or great spiritual first cause. Now the reason the American and the Briton are so near each other and understand each other so well, is that on the courses of the foundation of our respective civilizations where you come to the deep levels of the ideals and inspirations of conduct, the two nations are at one. No one but a sharer of our ideals could have made us tingle and thrill as we do under the spell of Kipling's Recessional; no one but an Englishman could have moved us as he who describes the self-immolation of the noble physician in the Bonnie Briar-Bush; no poet but an English one would have conceived that splendid ideal of a manly death at "Twilight and evening star," and "one clear call for me," with its hope to meet a "Pilot at the bar, when we put out to sea." The Americans rejoice to be the guests of men, sharers of our ideals.

But the Joint Meeting is not alone of Americans and English, it is of engineers, American and English. Our data of science are the same; the equation of the parabola, or the exponential expression for the expansion of steam under adiabatic assumptions are not changed as we cross the Atlantic. Why then the stimulus each feels in rubbing shoulders with the other? It is that economic conditions and the conditions of industrial production are different in the two countries. With the American the trend of successful production is in the direction of standard product as against special designs. In other words we seek to induce and persuade the buyer to adjust himself to such standard, rather than to have the buyer compel the seller to make special designs to meet a requirement which was

in most cases somewhat accidental and not unmodifiable. In economic terms, the American plan is to have the seller write the specifications; the English plan is to have the consulting engineer for the buyer write them. This difference explained American successes in recent competitive history, and threw a strong light on one phase of the "American peril." When the Briton woke up to the advantages of the other system, the days of certain supremacies would be numbered.

In the third place, this meeting was the successor of other transatlantic interchanges, beginning in 1889, repeated in 1893, 1900 and 1904 when the Institution came to Chicago and St. Louis for a visit; and to this last the present meeting was the return match or home game in the speech of the national sport.

Finally, did such a reunion of the great productive engineers of the English-speaking peoples, rejoicing in the same high ideals impose on the two bodies any responsibilities and obligations. Doubtless many, but at least one. The duty of the designer of machines and the manager and director of works to safeguard his work-people at their occupations, that useless and unnecessary loss of life or limb or wage-earning capacity was not entailed where it could least be borne. The air of America was vibrant with the sense of duty to prevent accident in factory and shop; and this was first the duty and opportunity of the trained mechanical engineer. To paraphrase the historic vision of the first violent death in our race: when Cain the older brother, the leader of men, the employer by temperament and gifts shall be asked, "Where is thy brother? The voice of thy brother's blood maimed or slain in a factory accident crieth out from the ground," the enlightened sentiment of all of worthy ideals will not allow him carelessly and indifferently to answer, "Am I my brother's keeper?" The mechanical engineer is responsible before the bar of the highest justice for any industrial accident which he could have prevented and did not interest himself to forestall. Let us see to it that this sin is not laid to our charge.

The Secretary then presented his account of the events of the trip and of the meetings, and spoke in particular of its international character of the gathering and of the impressive service in Westminister Abbey. He went on to speak of the national work of the Society, as evidenced in the recent organization meeting in San Francisco.

A paper by George A. Orrok of New York on The Transmission of Heat in Surface Condensation was then presented, which dealt with

the results of 771 heat transmission tests made on 16 kinds of condenser tube under the various conditions of condenser practice. The conclusions drawn by the author from these and other tests include a statement of the law of heat transmission in condenser practice, with reference to mean temperature differences, velocity of cooling water, effect of air leakage and effect of the material of which the tube is made. The paper was discussed by W. F. M. Goss, W. D. Ennis, Wm. Kent, H. H. Suplee and Thomas C. McBride.

WEDNESDAY AFTERNOON—STEAM ENGINEERING

The session of Wednesday afternoon was devoted to papers on Steam Engineering.

The first paper presented was by Edw. A. Uehling of Passaic, N. J., on Combustion and Boiler Efficiency, and maintained that the efficiency of the steam generator depended on conditions far more complex than the steam engine or dynamo. The importance of knowing the percentage of CO_2 in the flue gas and the stack temperature, which are the controlling factors in steam boiler economy, were particularly dwelt upon. The paper was discussed by C. H. Bathgate, W. D. Ennis, Wm. Kent. D. S. Jacobus, John C. Parker, A. W. K. Billings and H. C. Abell.

This was followed by a paper on The Automatic Control of Condensing Water, by B. Viola of Brooklyn, N. Y., which gave particular attention to barometric counter-current condensers in connection with vacuum pans, and was illustrated with many recording charts taken during operation. This was discussed by George Dinkle, Watson C. Shallcross and E. D. Dreyfus.

Two accounts of turbine tests were then presented, one on a 10,000-kw. Steam Turbine, by Sam. L. Naphtaly of San Francisco, giving the results of steam economy tests on a unit at the plant of the City Electric Company, San Francisco, with a description of methods, apparatus, and application of correction factors to meet specified conditions; and the other on a 9000-kw. Turbo-Generator Set, by F. H. Varney of San Francisco, with a description of tests and results. These were discussed by J. W. Lawrence, D. S. Jacobus, I. E. Moultrop, George A. Orrok, E. D. Dreyfus, Francis Hodgkinson, R. J. S. Pigott, W. L. R. Emmet and W. L. Waters.

The final paper of the session was by Isaac Harter, Jr., of Bayonne, N. J., entitled Notes on the Value of Napier's Coefficient with Superheated Steam, comprising a series of determinations of the value of

the coefficient for steam at pressures closely averaging 160 lb. per sq. in. abs., and for various degrees of superheat ranging approximately between 50 and 200 deg. This was discussed by Henry E. Longwell and Prof. R. C. H. Heck.

WEDNESDAY EVENING

A reunion of the membership of New York in honor of the newly-elected officers and visiting members of the Society, their ladies and guests, was held at the Hotel Astor on Wednesday evening, December 8. Dancing was begun at nine o'clock, those who did not care to participate occupying boxes, and supper was served during the intermission. The occasion, like those of a similar nature of previous years, was greatly enjoyed by all, and added much by the renewal of old acquaintances and the making of new ones, to the social side of the convention, emphasizing as it did the general feeling of friendliness which was so evident throughout the entire series of meetings.

THURSDAY MORNING SESSION

At the Thursday morning session four papers were read upon miscellaneous subjects. The first, A New Theory of Belt Driving, by Selby Haar of Schenectady, N. Y., presented a theory of the process by which a belt transmits power and a study of the losses occurring in the belt while under load, so that its efficiency may be determined. The paper was discussed by Carl G. Barth, Geo. N. Van Derhoef, H. G. Reist, A. F. Nagle, Harrington Emerson, F. W. Taylor, T. M. Phetteplace, George I. Rockwood and Wm. Kent.

A Graphical Method for Calculating Stresses in a Connecting Rod, by W. H. Herschel of New York, followed, which dealt with a method for finding stresses at any point of a rod of any shape. This was discussed by L. L. Willard.

Operating Conditions of Passenger Elevators was presented by Reginald Pelham Bolton of New York, who directed attention to the effects upon elevator work and economy of the passenger movement and traffic by reducing the period of actual motion and by increasing the time occupied in the operations of starting and stopping. It was discussed by Emanuel Hollander.

The fourth paper presented was upon Modern Shoe Manufacture, by M. B. Kaven and J. B. Hadaway of Beverly, Mass. This treated of the ancient methods of covering the feet, the old-time shoe shop

in which each workman was taught to make the entire shoe, the making of the hand-sewed shoe, the advent of the sole-sewing machines, the direct means of revolutionizing the shoe industry, and subsequent inventions substituted for hand work which finally led to the building of the modern shoe factory. Mr. Hadaway who presented the paper illustrated his remarks with some samples of the welt shoe which he had brought with him. The paper was discussed by Edwin J. Quinlan, Edward Robinson and R. H. Long.

THURSDAY AFTERNOON—MACHINE SHOP SESSION

Three papers on Grinding were presented on Thursday afternoon at a Machine Shop Session, the first, The Field for Grinding, by C. H. Norton of Worcester, Mass., dealing with the new idea of grinding as quick cutting, rapid reduction of stock, accuracy and economy, with modern machines, modern wheels that cut and do not abrade, and a knowledge of the science of the process, which, the author believes, is worthy of systematic coöperation on the part of the engineer. The second paper, Precision Grinding, by W. H. Viall of Providence, R. I., discussed grinding as an art, especially as related to the manufacturer's problems where not only the nicest accuracy is obtained, but where the rate of production is an important consideration. Modern Grinding Methods, by B. M. W. Hanson of Hartford, Conn., was the last of these papers, and described recent developments in grinding machines for cylindrical work and plane surfaces, with an account of new features of the cylindrical grinder whereby the work is sized automatically, and illustrations of pieces ground on a surface grinder, using a cupped wheel on a vertical spindle, which has a high rate of production. These papers were discussed by W. L. Bryant, A. L. DeLeeuw, H. A. Richmond, Geo. M. Jeppson, Henry Hess, Henry M. Leland, Oberlin Smith, O. Junggren, and J. Wendell Cole.

THURSDAY AFTERNOON—GAS POWER SESSION

At the meeting of the Gas Power Section, also held on Thursday afternoon, the annual address of the Chairman was made by James Rowland Bibbins, on Gas Power Development. Reports were received from committees, the Membership Committee reporting a steady and normal growth of high quality.

The Literature Committee had already published its results from

time to time in The Journal, but expected even better results during the year before the Section.

The Research Committee announced that its work had been turned over to the Research Committee of the Society. The Installations Committee reported progress and the Standardization Committee, having completed its work, was discharged. The Committee on Operations did not present a report in writing, but I. E. Moultrop, Chairman, announced that data from three or four producer gas power plants were expected shortly.

The Committee on Elections announced the following officers elected: Chairman, R. H. Fernald; Member of the Executive Committee, C. J. Davidson. The Chairman-elect was then escorted to the chair by Professor Breckenridge.

Two professional papers were also presented at this session, the first that by the late E. P. Coleman of Buffalo, on the First Large Gas-Engine Installation in American Steel Works, presented by E. E. Kiger, which described in a very thorough-going manner an installation made in the Lackawanna Steel Company with which Mr. Coleman was connected. From the viewpoints of continuity and reliability of service the installation was considered successful, and the economy of heat consumption was considerably in excess of that usual with compound steam engines. The paper was discussed by Joseph Morgan, Wm. A. Bole, George A. Orrok, Edw. A. Uehling, Charles Whiting Baker, E. D. Dreyfus, E. E. Kiger, George D. Conlee, and Louis Doelling.

A paper by Nisbet Latta of Milwaukee, entitled Notes on a Heavy-Duty Gas Producer, was then presented, in which the author called attention to the recent development of the heavy-duty gas engine and to the fact that the gas producer had not been developed of proper size and type to accompany these large units. Recent experiments on pulverized coal and air in the proportions required to burn the carbon to CO were also described. The paper was discussed by W. B. Chapman, W. E. Winship, and L. B. Lent.

THURSDAY AFTERNOON

On Thursday afternoon Mr. and Mrs. Westinghouse received the members and guests of the Society at the Hotel St. Regis from four to six o'clock. The delightful hospitality of the host and hostess, with which the Society has had opportunity on previous occasions to become acquainted, made this occasion one of the most enjoyable

social events of the Annual Meeting, and it was very largely attended, affording an opportunity to extend to Mr. and Mrs. Westinghouse a personal greeting.

THURSDAY EVENING

The concluding gathering of the Annual Meeting was on Thursday evening, when an illustrated lecture was given by Dr. Georg Kerschensteiner, Superintendent of the Industrial Continuation Schools of Munich. This address was a noteworthy addition to the attractive lectures which have been given at each of the recent Annual Meetings. Dr. Kerschensteiner has not only achieved marked distinction through his original and effective methods for industrial training but he is an entertaining speaker, and in presenting the subject used a remarkable collection of slides from views showing classes at work in the varied lines of industry in which the students of Munich are given practical instruction. These not only include the more familiar occupations, such as work in the machine shop, foundry, pattern shop, etc., but a great variety of miscellaneous occupations ranging from the artistic to the most utilitarian, such as the supply of food and the manufacture of common implements and utensils. The Society was able to enjoy this lecture through the National Society for the Promotion of Industrial Education, who had arranged for an address by Dr. Kerschensteiner in New York, and the meeting was held by them at this time, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Mining Engineers coöperating.

EXCURSIONS

A very fine program of excursions, sufficiently varied in their nature to meet all tastes, had been arranged by the committee in charge, F. H. Colvin, Chairman, and to these Friday, December 9, was entirely devoted. Many availed themselves of the opportunity of visiting the New York Public Library at Fifth Avenue and 42d Street, W. W. Christie acting as guide. The building which will not be opened to the public until May 1911 is, however, practically complete as to its interior decorations, with the exception of pictures and furniture, and a very good idea was gained of the appearance which it will present. The visitors were especially interested in the very fine marbles and woods as well as other materials which have been employed in its construction, and in the workmanship which is to

be seen throughout the building, presenting a finished result which may be favorably compared with other public buildings throughout the United States. The various automatic devices for the speedy delivery of books to the reading room, the wilderness of steel shelves in the stack rooms, and the printing and binding machines, were also interesting features.

A party of 25 took advantage of the invitation to visit the plant of Nelson Goodyear, Inc., Brooklyn, N. Y., to witness the process of oxy-acetylene welding. The party was conducted by E. H. White and was shown the new type of generator and the torches used by this company. Demonstrations of welding and cutting metals were made, after which there was a demonstration by Mr. André Beltzer of the welding and soldering of aluminum by the use of a new flux for this purpose.

About a dozen members visited the Hudson and Manhattan Power House in Jersey City, under the guidance of W. B. Yereance, where they inspected the generating plant for the Hudson River tubes, known as the McAdoo tubes, a trip made possible through the courtesy of Mr. G. McAdoo. They were met at the power house by Chief Engineer Sage who personally conducted the visitors through the plant and explained the different features and the reasons for their adoption by those in charge. Some of the members of his staff had also been detailed to answer individual questions or to explain features in which any one might be especially interested.

A party of 60 were conveyed by special car to the works of the Pond Machine Tool Company at Plainfield, N. J., under the guidance of W. L. Clark, where several of the recently developed reversing motor planers were in operation and various tests were made for the benefit of the visitors. Other special machines as well as the regular processes proved of much interest and appreciation was expressed on all sides of the interesting visit. Through the courtesy of the company luncheon was served at the plant, and a special car conveyed the visitors to the city.

A party of 20 under the guidance of L. P. Alford visited the Thompson-Lovelace Aeroplane factory at Fort George, New York City, and this proved to be one of the most interesting excursions. The machine used by Moissant in his flight from Paris to London was on exhibition, completely assembled, and another machine was in process of erection for Moissant for the flight which he is to undertake in February from Key West to Havana. Various engines and parts of aeroplanes under construction were shown the visitors.

The excursion party to the yard of the John N. Robins Company, Erie Basin, Brooklyn, though not large was composed of those especially interested in the application of electricity to this class of work, and particular interest was shown in the application of high tension, 6600 volt motors to the driving of air compressors; also, the pumping of basin dry docks by direct connected 6600 volt motors driving 30-in. centrifugal pumps. The large machine shop and boiler shop were also visited and the floating dry docks inspected, the new floating dry dock with steel wings and wooden pontoons coming in for particular attention.

A party conducted by S. B. Redfield spent the afternoon on Friday in the Spring Street Telephone Exchange and in the Long Distance Exchange on Cortlandt Street. The visitors were given an opportunity to see the work of the training school for telephone operators, which graduates 40 operators a week for the supply of the New York exchanges, and were shown the operation of the switchboards in the main room where 200 operators are in constant attendance. The procedure in securing a long distance call and in keeping track of the time and of the charges, and plans under way for securing even quicker service than is now obtained, were explained in detail by the representatives of the telephone company who accompanied the party.

Several of the members also visited the Navy Yard in Brooklyn.

In addition to the excursions which were participated in on Friday, a number of invitations had been received of which the members were at liberty to take advantage any time during the meeting. These included the Metropolitan Building, where Mr. Charles S. Bavier, chief engineer, received the visitors; the Interborough Power House, the Hill Publishing Company, the Waterside Power Plant of the New York Edison Company, Sims Magneto Company at Watsessing, N. J., the National Lead Company in Brooklyn, and the high-pressure fire-pumping stations of the Board of Water Supply of New York.

A party of the ladies who attended the Annual Meeting visited the Franco-American Food Company's factory in Jersey City on Wednesday morning and were escorted through this model plant by a special conductor. On Friday afternoon a trip was made to the Colgate factory in Jersey City which was also much enjoyed.

Every possible courtesy was extended to the visiting party at all these excursions and much appreciation was expressed to those who made the trips possible by throwing open their works to the Society. Material aid was rendered by the Information Bureau located in the foyer of the Engineering Societies Building.

ENTERTAINMENT FEATURES

As has been the custom for several years past, a number of the ladies resident in and about New York formed a Reception Committee, under the Chairmanship of Mrs. Herbert Gray Torrey, and added much to the social side of the convention by their entertainment of the visiting ladies and members. Tea was served on Tuesday and Wednesday afternoons, Mrs. John W. Lieb, Jr., acting as hostess on the former occasion, and Mrs. Jesse M. Smith at the latter. A Guides' Committee, Dr. Lucy O. Wight, Chairman, conducted parties to points of interest about the city, including the shops and hotels.

MEETINGS OF THE COUNCIL

DECEMBER 6

A meeting of the Council was held in the rooms of the Society on the afternoon of Tuesday, December 6, 1910, with President Westinghouse in the Chair. There were present Messrs. George M. Bond, Chas. Whiting Baker, R. C. Carpenter, H. L. Gantt, W. F. M. Goss, James Hartness, Alex. C. Humphreys, F. R. Hutton, E. D. Meier, I. E. Moultrop, H. G. Reist, W. J. Sando, Jesse M. Smith, Fred. W. Taylor, Worcester R. Warner, Fred. M. Whyte and the Secretary.

The minutes of the meeting of November 16 were read and approved.

Jesse M. Smith reported for the Committee on Constitution and By-Laws on the question of the change of date of the Annual Election and Meeting as stated in the Charter, and the desire to make it uniform with the Constitution and By-Laws. After reading the petition as drafted by the Attorney of the Society, it was

Voted: That the Secretary arrange for the formal presentation of the matter at the regular business session of the Annual Meeting, and that the same be duly executed and the record filed with the Secretary of the State of New York.

The Secretary reported the following deaths: George H. Baush, Lewis Johnson, S. W. Robinson, S. E. Stokes, E. P. Coleman and James Macpherson.

The Secretary read letters of appreciation from Messrs. S. B. Whiting and E. F. Mattes upon whom the Council had conferred Life Membership.

Voted: To refer to the Committee on Meetings the invitation from members in San Francisco to meet in that city for the semi-annual meeting of 1915, the year of the celebration of the opening of the Panama Canal.

Professor Hutton, Chairman of the Committee on Affiliated Societies, presented a letter from the Committee of the Providence Association of Engineers, concerning affiliation with this Society.

Voted: That the communication be received and the proposition for affiliation accepted with the understanding that the joint meetings of the two societies as stated in the application be understood to mean coöperative meetings as defined by the Committee on Meetings of this Society.

Voted: That the Annual Report of the Council covering the work of the year, including the reports of the Finance and other Standing Committees, be adopted and ordered read at the Annual Meeting.

Voted: To accept the following resignations: Guy Hopkins, New Orleans, La., Chas. A. Fingal, Chicago, Ill., C. A. Wettengell, Caney, Kansas, Burt S. Harrison, New York, C. G. Atwater, New York, W. B. Ridgely, Washington, D. C., and Herman M. Sage, Hawthorne, Ill.

Voted: To reinstate Thomas M. Keith, H. H. Dixon and W. F. Evans.

Professor Hutton presented his report of the Joint Meeting in England. It was the sense of the Council that he be asked to present this at the regular business session of the Annual Meeting on Wednesday morning.

This being the last meeting of the Council, on motion of Worcester R. Warner, Past-President, the members gave a rising vote of thanks to the retiring President, Mr. Westinghouse, and to the members of the Council of 1910.

The meeting adjourned.

DECEMBER 9

A meeting of the Council for the year 1910–1911 was held on Friday, December 9. Mr. George Westinghouse called the meeting to order and appointed Jesse M. Smith a committee to introduce E. D. Meier, the President-Elect, W. F. M. Goss to introduce G. M. Brill, Vice-President-Elect, and I. E. Moultrop to introduce E. B. Katte, Manager-Elect.

There were present E. D. Meier, President, in the Chair, George Westinghouse, F. R. Hutton, Jesse M. Smith, James Hartness, W. J. Sando, I. E. Moultrop, H. L. Gantt, George M. Brill, E. B. Katte, Chas. Wallace Hunt, W. F. M. Goss, H. G. Reist, Chas. Whiting Baker, Fred. W. Taylor and the Secretary. Regrets were received from Manager-elect Stanley G. Flagg, Jr.

The minutes of the meeting of December 6 were read and approved.

Voted: That Calvin W. Rice be appointed Secretary of the Council and the Society for the coming year on the same terms and conditions as last year.

Voted: That Prof. F. R. Hutton be appointed Honorary Secretary on the same terms and conditions as last year.

The Secretary reported a vacancy in the list of Vice-Presidents in the unexpired term of E. D. Meier, elected President of the Society, same to be filled under provisions of C 29. The Secretary was requested to cast a ballot representing the unanimous choice of the Council that Dr. Alex. C. Humphreys be appointed Vice-President to fill the unexpired term of E. D. Meier.

Voted: That John A. Brashear, Honorary Member, be appointed the representative of the Society on the John Fritz Medal Committee under the provision of C 46, to serve for a term of four years.

Voted: That Chas. Wallace Hunt, Past-President, be appointed Trustee of the United Engineering Society to serve for a term of three years under the provisions of By-Law 32, to fill the vacancy created by the expiration of the term of office of F. R. Hutton.

The death of Wm. H. Bryan, of St. Louis, was reported.

THE ANNUAL REPORT OF THE COUNCIL, 1910

The Council presents the following summary of the activities of the Society, supplementing the reports of its Standing Committees, which are part of the report.

The Council has held nine meetings during the administration year, from December 1909 to December 1910.

HONORARY VICE-PRESIDENTS

In response to invitations representatives have been appointed on the following occasions:

Jan. 17–19, National Civic Federation Conference in Washington, D. C., on Uniform State Legislation, Jesse M. Smith, Past-President, Chas. Kirchhoff, A. W. Burchard, E. G. Spilsbury, Fredk. M. Whyte, Vice-President, and Major Wm. H. Wiley, Treasurer of the Society; Sept. 26–30, National Irrigation Congress, Pueblo, Colo., C. H. Williams, Denver, Colo.; Sept. 5–9, Second National Conservation Congress, St. Paul, Minn., Paul Doty, J. J. Flather, L. H. Gardner, E. E. Johnson and M. E. R. Toltz; Sept. 27–29, Inauguration of President McVey, University of North Dakota, Calvin H. Crouch; Sept. 26, October 1, American Mining Congress, Los Angeles, Cal., H. H. Clark and Robert Linton; funeral of Chas. T. Porter, Honorary Member, Montclair, N. J., Alex. C. Humphreys, Hosea Webster, A. E. Forstall and J. E. McIntosh; June 19–23, International Congress of Mining, Metallurgy, Applied Mechanics and Practical Geology at Dusseldorf, Chas. Whiting Baker, Vice-President; Mr. Baker was also appointed from the Department of State as delegate on the part of the United States; June 4, Opening of the Forest Products Laboratory of the University of Wisconsin, Madison, Carl A. Johnson and J. G. D. Mack.

In the matter of the American Year Book in coöperation with other societies, and in the securing of biographies of engineers in coöperation with the Verein deutscher Ingenieure, the Secretary has been directed to assist so far as possible.

The changes in membership are shown in the following table:

GRADE	OCT. 1, 1909	LOSSES				ADDITIONS		NET INCREASE	OCT. 1, 1910
		Transfer	Resignation	Lapsed	Death	Transfer	Election		
Honorary..........	15	....	...	....	1	....	1	...	35
Members	2483	....	13	13	31	28	155	126	2609
Associates	394	28	3	4	5	1	40	1 decrease	393
Juniors	834	1	16	20	1	....	86	48	882
Total.......	3726	29	32	37	38	29	282	173	3899
Affiliates of Gas Power Section..................								....	145
Affiliates of Student Branches..								318	512

While there has been an absolute gain, it is smaller than that of other engineering societies.

It is hoped that the membership will take upon itself the acquainting of the leading engineers with the benefits of membership and the opportunity to extend its influence.

The following resignations were accepted during the year 1909–1910:

Edgmont B. Arnold, Jno. S. Avery, Richard C. Beverley, Albert E. Coleman, Asa S. Cook, Carl S. Dow, Harry Dunn, L. Hodgson, A. E. Holcomb, Zareh H. Kevorkian, George E. Kirk, Wellington W. Kuntz, W. A. McFarland, Henry E. Paine, R. Raymond, E. G. Rust, Foster C. Slade, Henry J. Scales, L. Searing, Ephraim Smith, J. E. Tatnall, Chas. J. Wachalofsky, Arthur S. Wardwell.

Membership which has lapsed during the year 1909–1910:

Arthur T. Alexander, Elmer T. Barnard, Wm. W. Bigelow, Frederick A. Boland, F. E. Bradenbaugh, James Breen, Jas. M. Briggs, E. D. Clarage, John G. Dodwell, Wm. F. Donovan, L. H. Gardner, Jos. N. Gregory, H. H. Hanna, Jr., Geo. O. Hodge, G. L. Holmes, Nathaniel Lombard, Chas. F. Meissner, E. E. Miller, John L. Mohun, Rafael de la Mora, James Naughten, Harvey E. Newell, W. Allen Pendry, H. W. Pudan, J. D. Ramsay, Warren B. Reed, Cyrus W. Robinson, D'A. W. Roper, Frederic Albert Schroeder, Edward Seaver, Jr., Robert M. Snyder, E. O. Spillman, George W. Stewart, Alfred A. Thresher, Chas. Henry Umstead, C. L. Weil, A. J. Wiechardt.

Members deceased during the year 1909–1910:

Mark Bary, Stephen Baldwin, Chas. Batchelor, Wm. P. Bettendorf, Jas. H. Blessing, J. H. Bloomberg, Jas. W. Bridge, Wm. W. Churchill, Chas. B. Clark, Wm. E. Crane, B. Cruikshank, Chas. B. Dudley, J. D. E. Duncan, R. W. Emerson, Jas. B. Faulks, Jr., C. F. Foster, Chas. H. Ferry, J. Garbett, A. M. Goodale, L. C. Grover, H. S. Haskins, Walter C. Kerr, John E. McKay, Wm. Metcalf, F. J. Plummer, Wm. N. Parsons, Chas. T. Porter, I. I. Redwood, P. A. Sanguinetti, T. H. Savery, Horace See, Gardner C. Sims, J. Henry Sirich, Jr., Wm. W. Snow, E. P. Sparrow, A. Spies, Chas. Swinscoe, C. H. Willcox.

On approval of the Membership Committee, John T. Jones and B. H. Cameron have been reinstated.

The Council has elected to Life Membership, S. B. Whiting and W. F. Mattes, who have been Members ever since the formation of the Society; and George W. Melville, Rear-Admiral, Past-President of the Society, has been made an Honorary Member.

On the Spring and Fall Ballots the following new members were elected and changes in grade of others authorized:

Elected June 1, 1910, Atlantic City: Members. W. J. Best, F. A. Blakeslee, Edward W. Brown, William L. Bryant, Henry Kenyon Burch, W. R. Carson, Cloyd M. Chapman, H. B. Chapman, Frank H. Clark, H. I. Cone, E. S. Cooley, E. H. Coster, A. D. Cressler, Byron Cummings, W. J. Davis, John A. Doane, D. Dorward, Jr., M. C. Ernsberger, R. W. Fenn, Harwood Frost, George W. Fuller, J. W. Fuller, Jr., David L. Gallup, Albert F. Ganz., Edwin S. Hallett, John Hays Hammond, W. H. Herschel, Alec. W. Hodgson, U. T. Holmes, F. Kingsley, A. Lebrecht, C. R. Lester, Wm. J. A. London, Harrison Loring, Jr., Chas. G. Lundgren, Adolphus A. McLeod, W. G. Marot, Irving S. Merrell, Frank H. Metcalf, John F. G. Miller, Lewis F. Moody, J. Wm. Neidhardt, Henry B. Oatley, Harry L. Parr, A. C. Paulsmeier, C. H. Peterson, Hollis P. Porter, Snowden B. Redfield, George R. Sanford, Eugene Y. Sayer, R. Schlatter, John J. Scollan, F. L. Sessions, W. C. Shallcross, Joseph D. Shaw, Elmer A. Sperry, Edson M. Stevens, Eliot Sumner, Theodore S. Tenney, W. E. Van Patten, V. S. Westcott, W. H. Whiteside, R. M. Wiggin, Paul Winsor, E. W. Wyatt, Lucien I. Yeomans, S. J. Zowski-Zwierzchowski; Promotion to Members. P. H. Batten, Frank Bishop, Jos. A. Bursley, Carl F. Dietz, R. W. Emerson, F. L. Kennedy, Roy Stevenson King, Frederick W. Mahl, S. M. Marshall, H. E. Satterfield, C. D. Young, John M. Young; Associates. Frank Burgess, S. P. Cobb, H. N. Cooley, Frank M. Sears, O. C. Thompson, Charles N. Thorn, Lawrence Whitcomb; Promotion to Associates. Wm. P. Hawley, Louis G. Henes; Juniors. M. L. Abrahams, John Adams, Alex. D. Bailey, Geo. A. Bancroft, Arthur F. Barnes, C. M. Barron, E. H. Bedell, Richard O. Bonner, J. B. Brady, Walter E. Brown, A. Bradley Burgess, Harold Thomas Carter, T. .D. Casserly, W. Van Alan Clark, H. H. Cook, William H. Cook, Glen H. Corlette, W. H. Correa, W. R. Crute, Geo. H. Cunningham, H. N. Davock, Ed. G. Dubarry, S. A. Ellenbogen, R. Emerson, H. V. Ennis, Stephen I. Fekete, J. O. Fisher, Walter J. Foley, George F. Gast, W. G. Gernandt, H. S. Gladfelter, Chas. C. Grant, Dwight K. Hall, H. D. Hartley, Fred M. Heidelberg, C. T. Henderson, Harry A. Hey ,Warren B. Hood, C. M. Husted, Austin D. Keables, H. B. Lange, W. H. Lines, J. Harold McCreery, H. B. McKibben, Thos. B. Morris, S. T. Mudge, B. S. Nelson, J. G. Painter, John H. Peper, Jr., William T. Price, Rudolph Roesler, Philip L. Ross, D. D. Rowlands, R. L. Rowley, R. P. Schoenijahn, J. T. Sharp, Jr., E. J. J. Sievers, Charles O'Conor Sloane, N. L. Snow, W. C. Sprau, R. K. Stockwell, Everett W. Swartwout, H. B. Taylor, Gerald E. Terwilliger, Charles Thoma, Jr., Walter Thoma, L. B. Webster, James L. Wick, Jr., R. A. Wilson, Forest E. Woodman, A. R. Zachert,

Elected December 7, 1910, New York: Members. Lawrence Addicks, Will H. Baltzell, H. H. Barnes, Jr., Dwight K. Bartlett, Oliver D. H. Bentley,

John C. Bird, George Wright Bowers, H. A. Brinkerhoff, Willard Brown, Forest E. Cardullo, J. D. Carr, Markham Cheever, Howard B. Clark, F. B. Cockburn, Arthur E. Cutler, Hans Dalstrand, W. R. Dunn, Charles L. Edgar, William J. Edwards, W. W. Erwin, Edmund H. Farquhar, John Fisher, Benjamin D. Fuller, Halbert P. Gillett, Philip M. Hammett, F. M. Hartman, J. R. Henderson, Chas. H. Herrick, Lewis A. Howland, Allen Hubbard, George Francis Hutchins, Chas. T. Hutchinson, A. L. Johnson, G. R. Joughins, O. F. Junggren, P. Junkersfeld, Karl W. Knorr, Gustav L. Kollberg, J. W. Ledoux, Norman Marshall, Frank Amedee Nazzur, Warren E. Murray, Walter S. Myers, Charles L. Norton, M. Webb Offutt, Francis Conrad Osborn, Oscar P. Ostergren, Perley Burnham Palmer, Geo. U. Poole, Edwin Jay Prindle, M. H. Putnam, Edward B. Richardson, Charles H. A. F. L. Ross, Will M. Sawdon, Phineas V. Stephens, Sidney Stevens, James Balboa Stokoe, Julian B. Strauss, Wm. Barrett Updegraff, E. Victoreen, G. R. Wadsworth, E. L. Walker, D. E. Washington, William P. Westcott, C. T. Westlake, Thos. R. Weymouth, Richard T. Wingo, John J. York; Promotion to Members. John H. Damon, James E. Gibson, Henry John Hanzlik, Arthur C. Jackson, Horace Judd, Wm. H. Kavanaugh, J. H. Maysilles, H. A. Moody, James A. Pratt, Geo. F. Read, Jr., Theodore Howard Taft, J. W. Taylor, J. G. Vincent, F. H. Vose, H. L. Whittemore, L. L. Willard; Associates. Freeman Field, Emil J. Heinen, M. T. Maguire, Ray Mayhew, John B. Perkins, W. R. Porter, G. E. Richardson, Arthur C. Scott,; Juniors. John F. Allison, Edward E. Ashley, Jr., H. Harding Bailey, W. J. Bailey, T. D. Banks, Henry C. Beckwith, Harry Lewis Benner, Myron R. Bowerman, Wm. Wallace Boyd, Harry S. Brown, R. U. Bunker, Herbert W. Carey, F. A. Collins, Jr., P. E. Cowgill, Magruder Craighead, Peter A. Cummins, Charles Iven Day, H. L. Doolittle, H. Alfred Ellis, John Fallon, W. W. Fisher, Arthur P. Gerry, Frank J. Gordon, Lucian L. Haas, H. F. Hallock, L. G. Hanmer, R. C. Hargreaves, Eugene Hunt, Frederick W. Ives, John R. James, Reid Jones, John P. Kottcamp, Milton Kraemer, Chas. H. Leaman, Nixon Lee, W. E. McCann, J. P. McJilton, W. R. McKinnon, C. H. Mount, John P. Mudd, Albin J. Nott, Harry Ottinger, H. H. Ramsey, John I. Rogers, Jr., James R. Rossman, Jr., Chris. A. Shearer, A. F. Sinclair, Harry St. Clair Spillman, Glegge Thomas, Robert H. Tifft, Albert C. Townsend, Samuel K. Varnes, Joseph W. Wattles, 3rd, Erwin L. F. Weber, Hugo W. Weimer.

MEMBERSHIP COMMITTEE

The Membership Committee have recommended this year for ballot 306 candidates, including 30 candidates for promotion, as compared with 339 last year, including 45 promotions. The general financial conditions prevailing in the country and the strictness with which the Committee is scrutinizing applications perhaps account for the slight falling off this year.

At the Spring Meeting amendments were adopted, the intent of which is to make the Associate grade no longer an intermediate grade between Member and Junior. These amendments appear in the report of the Constitution and By-Laws Committee.

STUDENT BRANCHES

The Council has been strict in its requirements for admission of Student Branches, and in general these are similar to those of the Carnegie Foundation for the Advancement of Teaching. There have been admitted to Student Membership since the last annual report, the University of Maine, Orono, Me., the University of Arkansas, Fayetteville, Ark., Yale University, New Haven, Conn., and Rensselaer Polytechnic Institute, Troy, N. Y.

PUBLIC RELATIONS COMMITTEE

An amendment to the Constitution was adopted at the Spring Meeting in Atlantic City which added the Public Relations Committee to the regular standing committees of the Society. The President appointed James M. Dodge, Past-President, Chairman, with associates, Robert W. Hunt, Past-President, Dugald C. Jackson, J. W. Lieb, Jr., Fred J. Miller. This committee will take up as one of its first duties the report of the committee appointed by the Council to investigate the proposed bill before the legislature of the state of New York looking to the licensing of engineers.

The special committee consisted of Chas. Whiting Baker, Chairman, Leonard Waldo and Alfred Brooks Fry, and their investigations have brought out considerable data on this in foreign countries.

PUBLICATIONS

Under the direction of the Publication Committee there have been issued twelve numbers of The Journal with approximately 2461 pages of text and 638 pages of advertising matter; and Volume 31 of the Transactions. The Year Book is now issued but once a year and combines the geographical and alphabetical lists formerly issued in January and July.

Fred R. Low has been appointed a member of the Publication Committee to serve the unexpired term of H. W. Spangler, resigned.

HOUSE COMMITTEE

The House Committee have completely the decorations of the rooms of the Society, including the Secretary's office. These improvements have received favorable comments from the members and others. The Society's rooms are now especially inviting and comfortable and offer a convenient place for making appointments.

LIBRARY

The Society has received 218 gifts of books during the year, 176 by purchase and 85 by exchange. By the coöperation of Founder Societies in the administration of the libraries of the three Founder Societies as one library and extending the benefits, it is hoped that in the near future a trained engineer and librarian may be engaged, looking also to possible coöperation with the New York Public Library when it moves to the new site near Society headquarters.

MEETINGS

Meetings of the Society are now being conducted in four cities. The Committee on Meetings having extended the privileges of the membership in Boston and St. Louis, have arranged for meetings of the Society in the cities of San Francisco and New York which shall be uniform with the first-mentioned cities.

During the past year there have been held 7 meetings in New York with an average attendance of 271; in St. Louis 6 meetings with an average attendance of 75; and in Boston 6 meetings, with an average attendance of 175, some in coöperation with other societies. At the inauguration of meetings in San Francisco the Committee on Meetings delegated the Secretary of the Society and Chairman of the Committee Meetings to be in attendance. Past-President Jesse M. Smith and the Secretary also attended a meeting in St. Louis during the year.

Two new committees have been appointed, one on meetings in New York, Walter Rautenstrauch, Chairman, Fredk. A. Waldron, Treasurer, F. H. Colvin, Edward Van Winkle and Roy V. Wright, thus not only making all meetings uniform but also giving the nucleus of an organization to take care of the social features of the regular annual meeting in New York. A Committee on Economic Administration of Industrial Establishments is being organized which shall have general responsibility for developing papers and meetings on that subject.

RESEARCH COMMITTEE

The Research Committee have prepared a list of laboratories of the various technical schools of the country. In addition to the name and location of laboratory, the data include the name of the director, the field of engineering for which the laboratory is equipped,

a list of subjects already investigated, the published reports, and a statement of problems under investigation. The Committee also has under consideration the development of a standard by which to judge the performance of safety valves.

STANDARD FLANGES

H. G. Stott, A. M. Mattice, J. P. Sparrow, and Wm. Schwanhausser have been appointed a committee to coöperate with the National Steam and Hot Water Fitters Association leading to the adoption of a uniform standard for flanged and screwed cast iron fittings.

IDENTIFICATION OF POWER HOUSE PIPING

The Committee, H. G. Stott, Chairman, H. P. Norton, Wm. H. Bryan, I. E. Moultrop, J. T. Whittlesey, appointed to report on the subject of standardizing the pipe coloring for power houses, advised the appointing of a special committee on the subject to establish at the earliest possible date a standard system of coloring. The same committee has been reappointed for this work.

LAND FUND COMMITTEE

On the resignation of the former Land Fund Committee, a new Committee was appointed by the Council, Worcester R. Warner, Chairman, C. N. Lauer, I. E. Moultrop, Geo. A. Orrok, F. H. Stillman. An active campaign has been started to clear the indebtedness of the Society for its share in the land on which the Engineering Societies Building rests, and $88,920.03 have been received to date, leaving $85,765.03 to be raised.

FINANCE COMMITTEE

The Finance Committee have taken an active oversight of the financial affairs of the Society and too much credit cannot be given for their conscientious work.

On account of the fact that election to membership occurs at a different date from that of the beginning of the fiscal year, at the request of the Council, the question of partial dues has been considered carefully, with the result that amendments have been adopted during the year and have become a working basis, as shown in the report of the Committee on Constitution and By-Laws.

CONSTITUTION AND BY-LAWS

Under the direction of the Committee on Constitution and By-Laws, the following amendments have been made to the Constitution, By-Laws and Rules:

C 10 An Associate shall be thirty years of age or over. He must have been so connected with some branch of engineering or science, or the arts, or industries, that the Council will consider him qualified to coöperate with engineers in the advancement of professional knowledge.

C 11 A Junior shall be twenty-one years of age or over. He must have had such engineering experience as will enable him to fill a responsible subordinate position in engineering work, or he must be a graduate of an engineering school. A person who is over thirty years of age shall not be eligible to membership in the Society as a Junior.

C 45 The Standing Committees of the Society to be appointed by the President shall be:

Finance Committee.
Committee on Meetings.
Publication Committee.
Membership Committee.
Library Committee.
House Committee.
Research Committee.
Public Relations Committee.

B 11 Each person elected to membership, except an Honorary Member, must subscribe to the Constitution, By-Laws, and Rules of the Society, and pay the initiation fee before he can receive a certificate of membership in the Society. Resignations from membership shall be presented to the Council for action.

B 16 The initiation fee and the annual dues for the first year shall be due and payable on the first day of the month following the date of the election of a Member, Associate or Junior. The annual dues for each ensuing year shall be due and payable in advance on the corresponding day in each year thereafter. Upon the payment of the initiation fee and the annual dues for the first year, the person elected shall be entitled to the rights and privileges of membership in the grade to which he was elected. The date of payment of a member's annual dues may be changed to the first day of any other month, and a pro rata adjustment of the dues made, by application to the Secretary.

B 17 A Member, Associate or Junior in arrears for dues for one year, on the first day of October previous to the Annual Meeting, shall not be entitled to vote, or to receive the Transactions or the publications issued by the Society thereafter until such dues have been paid. Should the arrears for dues or other-

wise be for more than two years, the name of such person shall be presented to the Council for such action as it deems advisable under C 24. Should the right to vote, or to receive the publications of the Society be questioned, the books of the Society shall be conclusive evidence.

B 18 The Council may, in its discretion, restore to membership any person dropped from the rolls for non-payment of dues, or otherwise, upon such terms and conditions as it may at the time deem best for the interests of the Society.

B 22 The Finance Committee shall consist of five Members or Associates. The term of office of one Member of the Committee shall expire at the end of each Annual Meeting. This Committee shall, under the direction of the Council, have a supervision of the financial affairs of the society, including the books of account. The Committee may cause the accounts of the Society to be audited and approved annually by a chartered or other competent public accountant. The Committee shall hold monthly meetings for the audit of bills and such other business as shall come before it and shall deliver to the Secretary for representation to the Council at the end of each fiscal year, a report of the financial condition of the Society for the past year, and also shall present therewith a detailed estimate for the probable income and expenditure of the Secretary for the following twelve months. It shall make recommendations to the Council as to investments, and when called upon by the Council, advise upon financial questions. It shall have charge of the making of all contracts and other obligations to pay money in the Society's work and the ordering of all expenditures thereunder.

B 24 The Publication Committee shall consist of five Members or Associates. The term of office of one Member shall expire at the end of each Annual Meeting. The Committee shall review all papers and discussions which have been presented at the meetings, and shall decide what papers and discussions, or parts of the same, shall be printed in the Transactions of the Society. The Committee shall have the supervision of the monthly publication of the Society known as "The Journal." The Committee will be expected to publish all such data as will be of assistance to engineers or investigators in their work. At the end of each fiscal year the Committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

B 37 The Annual Meeting shall begin in the City of New York on the first Tuesday in December and continue from day to day as the Council may direct.

The Annual Business Meeting of the Society shall be held on the Wednesday following the first Tuesday of December.

The Semi-Annual Meeting shall be held in such a place and begin on such a day as the Council may direct, and continue from day to day.

The Semi-Annual Business Meeting of the Society shall be held immediately preceding the first professional session of the Semi-Annual Meeting.

Professional meetings of the Society for the reading and discussion of papers and for topical discussions may be held at such times and places as the Council may direct.

Announcements of all meetings of the Society shall be published in The Journal.

A notice of each Annual and Semi-Annual Meeting and each Annual and Semi-Annual Business Meeting of the Society shall be mailed by the Secretary to each member in each grade not less than 30 days before the date of that meeting and at least 30 days before each Special Business Meeting.

R 24 Engineers and others not members of the American Society, but desiring to participate in the meeting of the Section, may enroll themselves as affiliates as heretofore provided with the approval of the Executive Committee of the Section. Such affiliates shall have the privilege of presenting papers and taking part in the discussions. They shall pay $5 per annum which shall be due and payable in advance, on October 1 of each year of their enrollment, and shall thereby be entitled to receive the regular issues of The Journal for a period covered by their dues.

R 29 The American Society of Mechanical Engineers will furnish monthly issues of The Journal to all members of affiliated organizations who are not members of The American Society of Mechanical Engineers upon the payment by each of two dollars per year, such payment being due January 1 of each year. The American Society of Mechanical Engineers will furnish gratis to each affiliated body, extra copies of advance papers for use at its meetings, the number furnished to be agreed upon at the discretion of the Secretary.

R 35 The tellers of election in counting the ballots for officers shall consider the ballot for an officer as valid, provided the intent of the voter as to that particular office is clear, even though his ballot as to candidates for another office may for any reason be invalid.

A special committee appointed to report on improvements in the methods of balloting now in use in the Society, Theodore Stebbins, Chairman, W. T. Donnelly and Chas. E. Lucke, have made a report which is to be considered at a joint meeting of the committees interested.

MEETING IN ENGLAND

The Secretary and Honorary Secretary presented reports of the enjoyable trip to England and the meeting with the Institution of Mechanical Engineers. The former report is in narrative form while the latter treats of the significance of international meetings.

The detailed reports of the Standing Committees are made a part of this report as they appear in The Journal for December.

THE NEWLY ELECTED OFFICERS FOR 1911

EDWARD DANIEL MEIER

President Am. Soc. M. E.

Edward Daniel Meier, president and chief engineer of the Heine Safety Boiler Company, was born in St. Louis, Mo., May 30, 1841. At the close of a scientific course at Washington University, St. Louis, in 1858, he studied for four years at the Royal Polytechnic College at Hanover, this being followed by an apprenticeship at Mason's Locomotive Works at Taunton, N. J. At the outbreak of the Civil War he enlisted in the Grey Reserves, the Thirty-second Pennsylvania, and served in the army of the Potomac until after the Battle of Gettysburg. He subsequently served in the Second Massachusetts Battery, also in the United States Engineer Corps, and finally became lieutenant in the First Louisiana Cavalry, seeing much active service and on May 30, 1865, receiving the surrender of Lieutenant-General John B. Hood and staff.

At the close of the war he entered the Rogers Locomotive Works at Paterson, N. J., remaining one year. From 1867 to 1870 he was associated with the Kansas Pacific Railway, first as assistant superintendent and then as superintendent of machinery, leaving there to become chief engineer of the Illinois Patent Coke Company. In 1872 he became manager of the Meier Iron Company, building its blast furnaces, and from 1873 to 1875 directed the machinery department of the St. Louis Interstate Fair. During this time he became actively interested in the St. Louis cotton industry and designed machinery for baling cotton, first with the St. Louis Cotton Factory and then with the Peper Hydraulic Cotton Press. In 1884 he organized the Heine Safety Boiler Company for the development in the United States of the water-tube boiler of that name, and has been its president and chief engineer ever since. He was also responsible for the introduction of the Diesel motor into the United States and until 1908 was engineer-in-chief and treasurer of the American Diesel Engine Company.

Colonel Meier was lieutenant-colonel and later colonel of the First Regiment of the Missouri National Guard serving about ten

years, and is a member of the Grand Army of the Republic and of the Loyal Legion. He has been active in a number of professional organizations, serving in 1881–1884 as treasurer of the St. Louis Engineers Club, in 1889–1890 as its president and also as secretary of the American Boiler Manufacturers Association, and in 1908–9 as president of the latter society and of the Machinery and Metal Trades Association.

In the Society he has been active on many committees, was one of the managers from 1895 to 1898, and has twice been elected vice-president, serving his first term from 1898 to 1900, and beginning the second in 1910, an office which he still held at the time of his election as president.

VICE-PRESIDENTS

GEORGE M. BRILL

George M. Brill was born at Poughquag, N. Y., in 1866. He prepared for college at Wesleyan Academy, Wilbraham, Mass., and entered Cornell University where, after covering the mechanical and electrical engineering courses, he was graduated with the degree of M.E. in 1891. In 1895 Mr. Brill also received the degree of M.M.E. He was at once employed by the Solvay Process Company, Syracuse, N. Y., as engineer of tests and for nearly five years was engaged in research work. In 1896 and 1897, he was engineer in charge of the construction of their plant at Detroit, resigning to accept the position of assistant manager of the construction and mechanical departments of Swift and Company. Early in 1900 he engaged in a general engineering practice, specializing in the complete engineering of manufacturing and power plants. A large number of important examinations and investigations have been made for financial and industrial purposes.

About a year ago a partnership was formed with H. C. Gardner, Mem.Soc.M.E., manager of the construction and mechanical departments of Swift and Company, under the name of Brill and Gardner.

For several years Mr. Brill has been retained as consulting engineer for the Solvay Process Company.

He is chairman of the Advisory Board of Engineers to coöperate with the smoke department of the City of Chicago.

Mr. Brill became a Junior member in 1891 and a Member in 1896 and was a member of the Council as Manager from 1904 to 1907. In addition, he is a member of the American Institute of Electrical

Engineers, Western Society of Engineers, American Association for the advancement of Science, American Society for the Promotion of Engineering Education, Union League Club of Chicago and Columbia Club of Indianapolis.

EDWIN M. HERR

Edwin M. Herr was born in Lancaster, Pa., May 3, 1860, and removed with his parents to Denver, Colo., in 1873, where he attended the public schools, leaving high school before graduation to work as a telegraph operator, first with the Western Union Telegraph Company, and later on with various railroads centering in Denver. In 1881 he entered the Sheffield Scientific School at Yale University and pursued the course in mechanical engineering, graduating in 1884 with the degree of Ph.B. He then served an apprenticeship as a machinist, first at the Altoona Shops of the Pennsylvania Railroad, and afterwards at the Milwaukee Shops of the Chicago, Milwaukee and St. Paul Railroad, after which he accepted a position as draftsman in the mechanical engineer's office of the Chicago, Burlington and Quincy Railroad. He later became successively engineer of tests, superintendent of telegraph and division superintendent of the Chicago, Burlington and Quincy, resigning the position of superintendent of the Galesburg Division of that road in 1890 to take the position of master mechanic of the Chicago, Milwaukee and St. Paul Railroad in charge of the shops at Milwaukee and the power and rolling stock east of the Mississippi River. In 1892 he was appointed general superintendent of the Grant Locomotive Works at Chicago and in 1894 made two trips to Europe on general engineering investigations relating largely to the building of locomotive works in Russia. He was at this time also connected with the Gibb's Electric Company at Milwaukee and later assistant superintendent of Motive Power of the Chicago and North Western at Chicago and Superintendent of Motive Power of the Northern Pacific Road at St. Paul.

In 1898 Mr. Herr came to Pittsburg as assistant general manager of the Westinghouse Air Brake Company, afterwards becoming vice-president and general manager, and in 1905 was elected first vice-president of the Westinghouse Electric and Manufacturing Company, his present position.

HENRY HAGUE VAUGHAN

Henry Hague Vaughan was born December 28, 1868, at Forest Hill, Kent, England, and was educated at Forest Hill School, Woodford, Essex. From 1885 to 1887 he attended the Applied Science Department, Kings College, London. In 1888 he became an apprentice at Nasmyth, Wilson and Company's Works, Patricroft, Lancashire, England, where he remained until 1890. The following year he was employed as a fitter with the M. S. & L. Railway at Gorton, Lancashire, and with the L. & S. W. Railway at Nine Elms, Middlesex. Later he became associated as machinist, draftsman and assistant engineer of tests and as mechanical engineer with the Great Northern Railway, St. Paul, Minn. He resigned in 1898 and became mechanical engineer with the P. & R. Railway at Reading, Pa., leaving there in 1899 to act in the same capacity for the Q. & C. Co., Chicago, Ill. In 1902 he became assistant superintendent of motive power with the L. S. & M. S. Railway, Cleveland, Ohio; and from 1904 to 1905, superintendent of motive power with the Canadian Pacific Railway, Montreal. Since that time he has been assistant to the Vice-President with the same company.

MANAGERS

DAVID FRANCIS CRAWFORD

David Francis Crawford was born in Pittsburg, Pa., December 4, 1864, and was educated in the public schools and in the Pennsylvania Military Academy.

In 1885 Mr. Crawford was apprenticed in the Altoona Shops of the Pennsylvania Railroad and from that time has been connected with the Pennsylvania Lines. In 1889 he was made inspector of the Test Department and from 1892–1895 he was master mechanic of the Ft. Wayne Shops. From 1895–1899 he was assistant to the superintendent of motive power of the Northwest System and from 1899–1903 superintendent of motive power, and from 1903 to date he has been general superintendent of motive power of the Pennsylvania Lines.

Besides being a Member of this Society, Mr. Crawford is a member of the American Institute of Electrical Engineers, the Master Car Builders' Association and the American Railway Master Mechanics

Association. He was sent as a reporter and delegate to the International Railway Congress at Berne, in 1910.

STANLEY G. FLAGG, JR.

Stanley G. Flagg, Jr., was born in Philadelphia, January 21, 1860, and was educated in a private school and in the Philadelphia High School.

In this same year he entered his father's works, Stanley G. Flagg and Company, as an apprentice, working through each mechanical department up to the successive positions of foreman, shop superintendent, foundry superintendent and junior partner. In 1909 he took over the sole ownership of the business.

Mr. Flagg is a member of the American Institute of Mining Engineers, the American Foundry Association, the American Society of Testing Materials, the British Iron and Steel Institute, the Staffordshire Iron and Steel Institute and other allied associations.

EDWIN BRITTON KATTE

Edwin Britton Katte was born in St. Louis, Mo., October 16, 1871. In 1881 he entered the Cutler School in New York City and eight years later Sibley College, Cornell University, from where he was graduated in June 1894, with the degree of M.E. During the summer of 1893 Mr. Katte traveled abroad, studying electro-hydraulic plants. Returning to Cornell University, he took up special work in the design of vertical marine type engines and in mechanical and electrical testing, and received the degree of M.M.E. in 1894. He then entered the establishment of Henry R. Worthington, where he began as a mechanic's helper, later passing to the testing department, and finally becoming a foreman in charge of erection. In the early part of 1896 he became assistant engineer in charge of the erection of the superstructure of the Park Avenue viaduct of the New York Central and Hudson River Railroad Company. Two years later he was placed in the drafting room in the chief engineer's department whence he was later advanced to the position of assistant engineer in charge of water supply, and in 1898 was appointed mechanical engineer in charge of the design and construction of heat, light and power plants, coaling stations and water supply. In December 1902 Mr. Katte was appointed electrical engineer and secretary of the Electric Trac-

tion Commission of the New York Central and Hudson River Railroad Company, under whose direction he had immediate charge of the electrical and mechanical engineering corps engaged upon the work of electrification of the various lines of that company in New York City and its vicinity.

Mr. Katte is also a member of the American Institute of Electrical Engineers.

NECROLOGY

WILLIAM HENRY BRYAN

William Henry Bryan died December 5, 1910, at Chicago, Ill. He was born August 14, 1859, at Washington, Mo., and received his early education at the country schools. In 1881 he was graduated from Washington University with the degree of M.E., having spent his vacation in the shops of the Missouri Pacific Railroad where he learned telegraphy and other railroad practices. Since that time he had been employed as a general assistant erecting engineer and salesman with Frank H. Pond; as local manager of the George F. Blake Co., as secretary of the Pond Engineering Company; and in 1889 as secretary and local manager of the Heisler Electric Light Company of St. Louis, Mo., then developing a long-distance series of incandescent lighting. In 1891 he went to Chicago as manager of the Western branch of the Yale and Towne Company. Since 1892 he had been a consulting mechanical and electrical engineer in St. Louis. During this period he constructed the water works at Washington, Mo., the power plants of the Imperial Light, Heat and Power Company, of the Coliseum, of the Grand Leader, of the Eli Walker Building, and of Ferguson and McKinney, St. Louis. He also rendered excellent service in practical smoke abatement for the Citizens' Association of St. Louis in 1892 and 1893.

Mr. Bryan was a member of the Engineers' Club of St. Louis, having served as secretary, vice-president and president; of the present Smoke Abatement Committee of the Civic League of St. Louis; of the American Society of Heating and Ventilating Engineers; of the St. Louis Railroad Club, the Mercantile Club, the American Water Works Association, serving on its Committee of Depreciation, and president of the Washington University Association. He became a member of the Society in 1891, and since 1906 had been an active and influential member of the Committee on Meetings, and as such was mainly instrumental in inaugurating and conducting a system of local meetings in St. Louis.

LEWIS JOHNSON

Lewis Johnson, one of the oldest members of the Society, was born in New Orleans, La., June 8, 1836, and was educated in private schools. Following a natural tendency for mechanics he entered the mechanical profession while very young and served both at shop practice and marine engineering. His education was gained by close and earnest study and by a wide experience which included, among other things, the designing and constructing of new machinery for the baling of cotton, ginning of moss, manufacture of ice, and propulsion of steamers. During the last few years of his useful life, Mr. Johnson was president and chairman of the Executive Committee of the Sewerage and Water Board of New Orleans, and of the Audubon Park Association, both directed toward civic improvement. At the time of his death, May 26, 1910, he was president of the Johnson Iron Works of New Orleans.

GEORGE HENRY BAUSH

George Henry Baush, Member of the Society, was born in Holyoke, Mass., April 9, 1870, and was educated in the public schools of that city. His technical training was gained from his father, who founded what is now known as the Baush Machine Tool Company, of Springfield, Mass. In 1896 he became general foreman and superintendent of the Baush Company and in 1904 was elected its vice-president and general superintendent, all designing of machine tools being entirely under his charge. In 1906 Mr. Baush became associated with Hill, Clark and Company, as manager of their Philadelphia office, resigning from this position to accept a similar one with the Fay Machine Tool Company of Philadelphia, which he retained until within a few months before his death on September 12, 1910.

SAMUEL EVANS STOKES

Samuel Evans Stokes, the son of Dr. John H. Stokes, was born at Moorestown, N. J., on October 3, 1846, and died at his home in Germantown, Philadelphia, on November 12, 1910. He was graduated from the Lawrenceville school in 1863 and immediately went into the machine works of Isaac P. Morris and Company in Philadelphia. Here he remained for four years, going from one department to another and becoming an expert machinist and draftsman. After

two years spent in large works in Detroit he formed a partnership with Alfred Parish, known as the Stokes and Parish Machine Works. In 1876 this firm obtained the concession for all the machinery required by the Centennial Commission and the exhibitors and were given entire charge of Machinery Hall and the erecting of exhibits, also building a steam elevator which ran from the main hall to the roof. Shortly afterward the firm began to build hydraulic elevators, which soon became their specialty.

In 1885 a serious nervous breakdown made it necessary for Mr. Stokes to retire from active business, and the firm was taken over by the Otis Elevator Company of New York. In 1896 Mr. Stokes went abroad with his family, remaining in Europe for two years.

OLIVER S. SHANTZ

Oliver S. Shantz was born at Breslau, Ontario, Can., August 12, 1863, and received his early education at the Berlin and Ithaca high schools. From 1879 to 1886 he was apprenticed to J. Y. Shantz and Sons, Berlin, Ontario, manufacturers of automatic machinery. In 1893 Mr. Shantz was graduated from Sibley College, Cornell University, with the degree of M.E. and six years later received a master's degree in mechanical engineering from the same university. He was successively engaged as engineer and designer for Schaeffer and Budenberg for one year; as instructor in mechanical engineering at Cornell University for four years; as draftsman for the Otis Elevator Company; salesman for the Tonkin Boiler Company, New York and assistant engineer with the Edison Portland Cement Company. In 1901 Mr. Shantz affiliated himself with the Rand Drill Company, representing them in Chicago, and while with this company made a speciality of sand pumping, installing many large plants of this character. In 1905 the Rand Company was merged into the Ingersoll-Rand Company of New York and Mr. Shantz took charge of their interests in Detroit. Four years later he re-entered the employ of J. Y. Shantz and Son Company, Buffalo, N. Y., manufacturers of buttons, in the capacity of assistant manager.

Mr. Shantz died on September 7, 1910, after an illness of a few days. He was a member of the Society, the Manufacturer's Club and the Chamber of Commerce, Buffalo.

THE CONTINUATION SCHOOLS OF MUNICH

By Dr. Georg Kerschensteiner[1]

Director of Education, Munich

When I became director of education, it was evident to me that our educational institutions, and especially those concerned with the mass of the people, support neither industry nor state. In Germany over half a million children leave our elementary schools every year at the age of fourteen, the very age at which character begins to form and guidance is most necessary.

When the primary school was established at the beginning of the nineteenth century, seven or eight years of attendance sufficed. At that time Germany was not a thickly populated country, custom held sway in trade, and tradition in the family, both in rural districts and in the towns. Today the German State is an over-populated industrial community in which custom is disappearing and unfettered individualism seeks to overturn tradition, in which half of the rising generation receives neither the discipline of a well-ordered family life nor a training in the duties and obligations that will rest on them as citizens. Between 1860 and 1875 the German State acknowledged that the existing elementary schools were insufficient to impart necessary education, and the public continuation school arose. At Munich, for instance, two types of this school were founded in 1875, one for apprentices and the other for journeymen and foremen. The first was a general school of three standards, with from five to eight hours of instruction per week, compulsory for all boys in Munich between the ages of thirteen and sixteen and was organized as an extension of the so-called general education of the elementary school. No regard whatever was paid to the pupil's trade. Instruction was given for five hours on Saturday and for three hours on one after-

[1] Address given under the auspices of the National Society for the Promotion of Industrial Education, with The American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Mining Engineers coöperating, in the Auditorium of the Engineering Societies Building, Thursday evening, December 8, 1910.

noon during the week, the subjects being reading, writing, arithmetic and drawing. At the continuation school for journeymen, attendance was optional and the subjects of instruction were drawing, painting, modelling and chasing. Attention was paid almost exclusively to draftsmanship and the hobby of drawing was ridden to death. The school never thought of giving instruction in the management of a cost book, the preparation of specifications, or in bookkeeping. It totally ignored the fact that while the economic conditions of the present day require a technical and commercial training from the worker, the social conditions imperatively demand for him a civic training. Instead of realizing these requirements, the school too often misdirected the pupil, making a moderate artist out of a good decorator and a second-rate furniture designer out of a good joiner, an engineer out of a watchmaker.

Similar institutions arose in other German towns, at first arranged for voluntary and later for compulsory attendance. But while the voluntary continuation school got thousands of pupils who were totally uneducated for their life-struggle, the general compulsory school was regarded by its pupils with indifference. The employer looked on it as a burden and the pupil considered it a waste of trouble. All concerned were glad when attendance ceased and few of the apprentices ever thought of making use of the opportunities offered by the day or evening trade schools.

The barrenness of these schools became notorious. During the last decade of the past century the general continuation schools for boys were replaced by trade continuation schools modelled on those of Leipzig, Vienna and the Grand Duchy of Baden. This was a great step forward. Apprentices from the same trades could now be enrolled in the same classes and it was possible to adapt the curriculum to the actual needs of the pupil. Nevertheless, the problem of the continuation school seemed to me to be still unsolved. The more I studied these schools during my journeys of inquiry in Germany, Switzerland and France, the more clearly did I see their incompleteness. The instruction was given, as a rule, in the evening when both the pupils and the teachers were worn out. Though the school endeavored to make the pupil's trade the focus of interest, yet the instruction lacked the breath of life. A few individual employers, and here and there an association of employers, took a languid interest in it. The bond of union between the school and the workshop was still wanting. The boy got, it is true, training in the requirements of his trade, but no one laid emphasis on the most important side,

the practical work. Above all, it was forgotten that the boy was intended to become not only a good worker but also a good citizen, that the man was not to disappear in the laborer nor the future citizen in the apprentice. It was forgotten that modern states have placed power in the hands of the people, that the laziest and roughest day laborer has an equal voice with the cultured statesman and the philosopher in the government of his country, and therefore, that the most capable of our working classes ought to get a thorough insight into their duties as citizens. In a word, it was forgotten that civics is at least as necessary an element in the syllabus of our continuation schools as are drawing and arithmetic. Therefore, I recommended not only to my city, but also to the Prussian Royal Academy, a wholly new organization.

During the several times I have been in Scotland, England and the United States, I have seen that these nations keep the true import of this great task well in view. In that excellent book by Professor Sadler, Continuation Schools in England and Elsewhere, I find a quotation from circular No. 374 of the Scotch Education Department to this effect: "School work has for its aim and end objects more important than preparation, in the narrow sense, for any particular occupation. It should aim at producing the useful citizen imbued with the sense of responsibility and of obligation towards the society in which he lives: it should render him, so far as the school can do so, fit in body and alert in mind and should prepare him for the rational enjoyment of his leisure time as well as fit him for earning his living." In truth, that is the end and aim of all schoolwork and especially of the work of the continuation schools. How then is it to be attained? On what principles are the continuation schools to be organized, so that they may give a boy not merely instruction in his trade but also an education in citizenship? Time will not permit me to enlarge on the arguments that influenced us in Munich, but while I describe what we have done I shall be able to touch incidentally on our motives.

The first step was to connect the craft school and practical instruction with all trade continuation schools. Thousands of boys have only a one-sided apprenticeship and thousands more lack even this. We must inspire them with the joy that springs from thoroughness of work. They must learn to appreciate the moral effect of good work on their own personalities. If we put the craft school and practical training, instead of textbooks and mere words in the forefront of instruction, we gain the good-will of the pupils at once. This being

so, there is no difficulty in leading them to appreciate allied branches of school work, such as drawing, arithmetic, bookkeeping, technology and the knowledge of materials, tools and machines. The interest aroused by practical work will be transmitted to all these allied subjects.

Through considerations of this kind, I was strongly convinced that a carefully devised scheme of manual instruction ought to form part of the curricula in the highest classes of the elementary school, and that this should be done in the interests both of general education and of any particular trade that the pupil may join after leaving school.

The second point was to enlist the active sympathy of the different associations of employers. Here we were assisted from the outset by our own school workshop. For the employers, seeing that apprentices took an increased interest in their work and finding them more efficient, gave our teaching the credit. In order to gain the support of the associations we permit them to inspect our schools, to advise us regarding their progress and to assist us in the choice of foremen and journeymen as teachers. We also consult their wishes as to the time table and invite their opinion on the syllabus of instruction. In return for these opportunities, we expect them to supply models, tools and machinery and also, within reason, to provide raw materials, to make attendance possible during more suitable hours of the day, and to put pressure on apprentices to attend the regular classes.

In this manner we have combined rights and duties, privilege and obligation. And we have found that the more the employers use the opportunities we have given, the more ready they are to make sacrifices for the schools; and that the more they come to appreciate the value of the work being done in the schools, the more conscious they become of community of interests.

The trade continuation schools being thus fairly started with the good-will of the employers' associations, it was possible to attack the third group of difficulties, the time table. So far as quantity is concerned, we demand from eight to ten hours per week according to the trade. In addition, we arrange voluntary classes or special courses for further practical training and for gymnastics. So far as the hours of instruction are concerned, we have decided to give no instruction on Sunday and to arrange no compulsory attendance in the evenings after workshops are shut. As a rule we demand at least two afternoons per week from 2 o'clock to 7, or one afternoon

and one morning, or one whole working day. We have trade continuation schools where the apprentices come at 7 in the morning and remain till 6 in the evening. The associations of employers have shown themselves ready to give us an increased amount of time and the more the employers become aware of the advantage of the school, the more willing they are to comply with our requirements. In return, we pay attention to the social and economic conditions of every single trade. We use the dull season more for instruction than the busy time and we can always arrange short courses for workmen temporarily out of employment. Builders and decorators receive twelve hours of instruction from 5 p.m. to 7 p.m. every week from October 15 till March 15. For the rest of the year they get three hours on a week day. Other trades get ten hours per week for eight months of the year instead of nine hours per week for the full term of ten months. Thus the goldsmiths and the confectioners get December as a school holiday and the hairdressers are free during the carnival time. In all cases the organization is the result of an understanding with the representatives of the trade concerned. But, however varied the details, there is a general agreement on the main principle: that every apprentice must attend the continuation school during the whole time of apprenticeship or until the completion of his eighteenth year.

These three features of the new organization have inspired the school with vigorous life. Never in the course of my existence, has it become so evident to me that a rational education produces marvellous effects, not only in the pupils but also in the employers, and that with the delight of successful work the harsh selfishness of the individual is disappearing; that the need for the formation of a single great community is realized; and that the hope of a good harvest strengthens the readiness for sacrifice.

The growth of common interests has been as noticeable among apprentices as among employers. The man at the next bench has become a comrade partaking of the same pursuits and a critic worthy of attention. The teacher is no longer a stranger but a foreman or journeyman of the pupil's own trade with whom he may have to coöperate later, whose rival he may possibly become, one who, nevertheless, is endeavoring to develop in his juniors the qualities which will make them worthy successors. The red-tape of educational authority and the suspicious visits of the attendance officer disappear. The pupil is conscious of the support of the employers' association, whose personal sympathy and unselfish care soon enlist

his support in its favor. Thus it is, you will readily understand, that *esprit de corps* flourishes apace under these fortunate conditions and promises to yield us in riper years that larger sense of public spirit which we call love of our native land.

Thus is the ground being prepared for our fourth and main task, the inculcation of civic responsibility. By this I mean the recognition of the relations between the interests of the individual and those of the community and a just appreciation of the tasks the state has to fulfil. When the boy's soul has been aroused by the practical work of the school, there is no longer any difficulty in rendering his mind susceptible to this training. The interest he takes in his trade is increased when he comes to study the history of his trade. But the history of his trade is necessarily connected with the history of mankind in general. By observing the rise and decay of his vocation in the course of ages, he is introduced to the complicated conditions of the present day. The historical method which reveals step by step the mutual dependence of all sections of humanity, which traces the deep-seated relationship of vocations, people and states, teaches the pupil the necessary limits of self-interest and the obligations that membership in a state imposes on him. A great number of trade schools find here a vast field of exploration. Consider the history of such important trades as the goldsmiths and the builders; consider the textile industries, the mechanical industries and the oldest of all industries, agriculture. What a wealth of illustration their history affords us! All this instruction must, of course, be of an elementary kind and based on illustration by concrete example. By giving one hour per week for three or four years to this instruction we manage to get most of our pupils to understand the functions of our economic, social and political institutions. They come to consider not only their personal position and the position of their trade, but their views expand to a consideration, first of their native country and then of the complicated conditions of international intercourse. Thus they slowly learn the truth of the maximum that the meaning of life is not to rule but to render service, service to one's neighbor, service to one's town, service to one's native country, service to truth and justice.

Our pupils ought not only to learn what it means to be a citizen, they must also learn to act as good citizens. For this reason we seek to introduce some kind of self-government into our continuation schools so that the pupils may undertake something for the good of the school and of their comrades. The well-organized school affords

us plenty of opportunities, which have for a long time been utilized in the best British and American schools, but so far we have neglected them in Germany.

The essential features of the compulsory trade continuation schools of Munich are thus summed up in these four points: (*a*) practical work is made the center of interest; (*b*) the active sympathy and coöperation of employers on the one hand, and of trade societies and guilds on the other, is enlisted on behalf of the schools; (*c*) the time of instruction is sufficient in amount and excellent in quality; (*d*) every opportunity that presents itself for training the citizen is utilized.

So far I have spoken of the trade continuation schools. In addition to them, we have 12 local continuation schools in which boys are enrolled who are not yet apprentices, but who are engaged in casual and unskilled labor or who cannot be provided with a special continuation school because their numbers are too few. But while in the trade continuation schools the instruction includes German literature, commercial correspondence, commercial arithmetic, bookkeeping, knowledge of tools, machinery and materials, civics and hygiene, technical drawing and practical work, religion and, if required, physics, chemistry and gymnastics, the instruction in the local continuation schools bears a more general character, laying stress on practical work, gymnastics, hygiene and civics. In both types of school, the development of responsibility and initiative is encouraged. The trade continuation schools have their own buildings, of which I will show you views later, but the local continuation schools have been housed in primary schools and placed under the supervision of the headmasters of these schools.

During the present year we have in all, about 9400 boys between the ages of 14 and 18, and 2700 journeymen as pupils. In the year 1911, when the original class of apprentices will have completed the full course, we expect to have 10,000 boys and about 3600 journeymen enrolled in these schools.

The organization of the trade continuation schools will be best explained by considering the engineers' school. This is open to all apprentices in engineering, electrical and instrument-making works. It has four consecutive grades each representing a year of school life. The school meets for nine hours per week. The teaching is taken on week days, either in the mornings or in the afternoons, but never later than 7 p.m. Those apprentices who wish to get more practical work may attend optional continuation classes from 7 to 9 p.m. If

an apprentice does not make satisfactory progress he may be required to repeat attendance at a class for a whole term. The engineers' school has at present from 500 to 600 apprentices who are taught in about 24 classes. Instruction is given either by skilled workmen, that is, foremen or journeymen, or by trained teachers from our primary and higher public schools. The appointments are either as permanent or as visiting teachers. One condition is rigidly observed: all workshop instruction is given by a master or journeyman. Great care is taken in the preparation of the teachers for their task. On this point I must ask you to refer to Mr. Stockton's article in Mr. Sadler's book, as I have still an important section to deal with at some length, the continuation school for girls.

We have two kinds of continuation schools for girls, an optional school and a compulsory one.

The compulsory school is organized in three standards, each representing a year of school life, with three hours of attendance per week, for girls between the ages of 13 and 16. For girls who can spare more time there is also an optional continuation school with from six to ten hours of instruction per week. In both cases all instruction is given before 6 p.m. and, as in the boys school, no fees are charged.

To educate the rank and file of the people in this manner—the boys from 14 to 18 years and the girls from 13 to 16—is naturally expensive, and more expensive for boys than for girls. But the continuation schools are not so expensive as the primary schools. The average cost of the primary pupil is $24 per annum, while in the compulsory continuation school for boys it is $18 per annum. During the present year our primary schools with 70,000 pupils cost $1,700,000; the boys' continuation schools, with 9400 pupils, cost $300,000, and the continuation school for girls with 10,500 pupils, cost $70,000.

These schools exist at present in this perfection only in Munich. I have already said that Würtemberg has adopted the same organization for the whole country, that similar institutions are to be found in Baden, that the canton of Zurich in Switzerland has quite recently promulgated a new continuation-school law which in many respects resembles its Munich predecessor, and that, finally, the city of Vienna has erected at enormous cost a central building for apprentices' continuation schools, the framework of which is exactly the same as in Munich. Thus you see that South Germany, Austria and German Switzerland have started on the road of Munich's continuation-

school organization. In north Germany, the greatest energy is being expended, too, on the problem of compulsory continuation schools, but at present without any attempt to base the organization on the school workshop.

The reason for this must not only be sought in the fact that pedagogical opinion in Germany is still very strongly permeated with the idea of so-called general culture, but also in the difference between the south German and the north German employer. The latter is mostly an ardent opponent of the school workshop. Another reason is, perhaps, the difficulty with which organizers and school men make up their minds to accept the innovations of a colleague. It is a fundamental characteristic of human nature that everyone who has a question to solve likes to contribute his own share to the solution. There is a German riddle that illustrates what I mean: "What is the difference between God and a German Professor?" and the answer is, "God knows everything, and the German professor knows everything better." This knowing better is always a hindrance towards the quick realization of a good thing. I do not wish to throw a stone at anybody, for we all can make the same observation about ourselves. We are all inclined to know things better than our colleagues. When we have worked ourselves into a special hobby, consistently and energetically for many years, it is unspeakably difficult so to enter into the ideas of another man who does not agree with us, that we can do him justice on all sides. Nevertheless, experience will show in the case in question that the purely theoretical continuation school which entirely avoids practical teaching, will not fulfil its purpose. In your country, it is hardly probable that this experience will be necessary. You have already excellent school workshops of various kinds, the value of which for the education of the man, as opposed to the workman, has been brilliantly demonstrated in the publications of the National Society for Promotion of Industrial Education. The essential reason why the continuation school should not become a purely theoretical school is that its limitation to theoretical instruction would form an almost insuperable barrier to transforming our schools into educational institutions for community life. The transformation of schools into institutions of this kind, or, as I prefer to express it, into communities of labor, is the fundamental problem of all school organization. Its solution is the task of the present century. So long as our schools of all kinds, not the continuation schools alone, are not organized as communities of labor, they will not prepare their scholars as they should for the great labor

community that surrounds us—the state. I can give no better illustration of what I mean than in a quotation from your excellent countryman, Prof. John Dewey, in his Moral Principles of Education.

> I am told that there is a swimming school in a certain city where youths are taught to swim without going into the water, being repeatedly drilled in the various movements which are necessary for swimming. When one of the young men so trained was asked what he did when he got into the water, he laconically replied, "Sunk." The story happens to be true; were it not, it would seem to be a fable made expressly for the purpose of typifying the ethical relationship of school to society. The school cannot be a preparation for social life, excepting as it reproduces, within itself, typical conditions of social life.

All our present schools are such swimming schools on dry land as far as social education is concerned. We may give our pupils a vast amount of instruction as to their relation to state and society. But we do not accustom them to regard their work from this point of view, and give them no opportunity of making practical use of their knowledge in the service of their fellow pupils. Our schools are therefore not schools for social service. But nothing could be better adapted for this purpose than the continuation schools I have described, in so far as they are intimately combined with workshops and laboratories. For there is no place more suitable for uniting scholars for community of labor than workshops, laboratories and experimental gardens.

The only path to real state community of labor is to accustom the rising generation from its earliest year to place its work not only in its own personal service, but also in the service of its youthful companions. Only thus can we hope to develop the two great fundamental virtues of devotion to aims outside ourselves, and of consideration for the interests of others. And only thus will it, in all probability, be possible to preserve our great modern constitutional states from the dangers that threaten them through their own industrial, economic, social and political development.

PRESIDENTIAL ADDRESS

By George Westinghouse, Pittsburgh, Pa.

President of the Society, 1910

A year ago I was honored by my election to the presidency of The American Society of Mechanical Engineers. In accepting office, I expressed an apprehension that other duties of an onerous character might prevent a fulfillment of your reasonable expectations, and I fear that when all is summed up, you will agree that such an apprehension was well founded. I desire at once to express a sense of my obligations to my associates for their helpfulness and consideration in aiding me partly to discharge my duties. Although my time for the Society's work has been very limited, I have had many occasions to observe how efficiently the splendid organization which controls your affairs has performed the various duties involved in the development and management of an engineering society.

The chief event of the year was the Joint Meeting of the Institution of Mechanical Engineers with our Society in Birmingham and London. From all sides have come evidences of the success of those meetings and of the great benefit of their deliberations to engineering. The welcome extended by our brother society to those of our Society who were present exceeded in cordiality and completeness the expectations of those who knew that there would be a warm and full-handed reception, and nothing was lacking in the perfection of arrangements for the meetings and for the comfort and pleasure of our members and their ladies.

In these days, the effects of such international meetings and interchanges of good-will cannot fail to be lasting, especially in promoting those relations which stand for the advancement of science and commerce, as well as those broader international relationships which tend towards the conservation of peace between all countries.

Presented at the Annual Meeting of The American Society of Mechanical Engineers, December 1910.

Of almost equal importance was the joint meeting of members of the engineering societies held in Boston on January 21, which had been brought about by a member of our Society, Professor Hollis, of Harvard University. On this occasion about four hundred members of the engineering societies were present, including eight presidents of engineering societies or institutions, besides prominent members of many others, including architectural and scientific societies closely identified with the work of engineers.

Under the well-defined policy of your Council and officials, the members of our Society in Boston, St. Louis and San Francisco have been encouraged to hold important local meetings, and in this manner to bring the widely scattered members of the Society into more intimate relations with each other and with our affairs in general, and it is the purpose to extend our efforts in this direction as rapidly as circumstances may indicate.

My contributions to the discussions of matters of interest to our Society have been a short address, appropriate to the occasion, at the joint meeting of engineers in Bǒston, in which I laid stress upon the desirability of establishing, by coöperation between all engineering societies, such general standards in the construction of electrical and mechanical apparatus as would tend to reduce cost, increase efficiency, and lessen our difficulties.

In a more carefully prepared address, presented at the Joint Meeting in England, I urged the importance of an early decision on the part of those interested as to uniformity in the essential features involved in the electrification of railways. The discussion of this paper emphasized the necessity for early action on the recommendations made in regard to the selection of standards to meet the very few essential requirements.

As often happens in the discussion of a complex problem, some of the speakers misinterpreted my address and concluded that the paper specifically recommended the adoption of one particular system out of several well-known systems as a universal standard, whereas my specific recommendations were stated as follows:

"The additional fundamental requirements for electrically operated railways are:

(*f*) A supply of electricity of uniform quality as to voltage and periodicity.

(*g*) Conductors to convey this electricity so uniformly located with reference to the rails that, without change of any kind, an electrically fitted locomotive or car of any com-

pany can collect its supply of current when upon the lines of other companies.

(*h*) Uniform apparatus for control of electric supply whereby two or more electrically fitted locomotives or cars from different lines can be operated together from one locomotive or car. .

"Outside of economy in capital expenditure and economy and convenience in operation by steam or electricity, it matters not whether each locomotive and car and the apparatus upon them differ from every other locomotive and car in size or details of construction, so long as the constructions are operative and the materials employed are used within safe limits."

The selection of a system embodying these fundamental requirements would leave to manufacturers and inventors the same latitude for development and improvement in the construction of railway electrical machinery as has always existed with reference to steam-operated railways, where the fundamental requirements were: a standard gage of track, standard couplings of cars, and standard braking and signalling apparatus. To appreciate this observation, one has only to contrast the locomotive of twenty years ago with the mammoth Mallet compound locomotives which are now being introduced, or the freight car of ten tons capacity with the modern steel car of fifty tons capacity.

I cannot impress too strongly upon the members of this Society the great importance of lending their aid to bring about such an early decision in regard to the standards to be adopted in the electrification of railways as will insure to the traveling public the benefit of this method of transportation at the earliest possible moment and on an advantageous basis to the railways, which will be required, even under the most favorable circumstances, to expend vast sums of money in changing from steam to electric operation.

It has been suggested to me that it would interest the members of the Society to have a short account of the conception and development of the air-brake, to form an authoritative statement for the records of the Society, and as I believe I am chiefly indebted to my work in developing the air brake and introducing it upon railways for the honors you have conferred upon me, I have pleasure in complying with such suggestion, especially as a statement of the conception and development of the air brake will supplement what I have heretofore said in regard to the benefits to be derived from the standardization of mechanical devices.

To deal comprehensively with a subject which involves an experience of nearly forty-five years would require much more of your time than should be taken on this occasion. I will, however, present as briefly as possible some of the salient points.

My first idea of braking apparatus to be applied to all of the cars of a train came to me in this way: a train upon which I was a passenger between Schenectady and Troy in 1866 was delayed a couple of hours due to a collision between two freight trains. The loss of time and the inconvenience arising from it suggested that if the engineers of those trains had had some means of applying brakes to all of the wheels of their trains, the accident in question might have been avoided and the time of my fellow-passengers and myself might have been saved.

The first idea which came into my mind, which I afterwards found had been in the minds of many others, was to connect the brake levers of each car to its draft-gear so that an application of the brakes to the locomotive, which would cause the cars to close up toward the engine, would thereby apply a braking force through the couplers and levers to the wheels of each car. Although the crudeness of this idea became apparent upon an attempt to devise an apparatus to carry the scheme into effect, nevertheless the idea of applying power brakes to a train was firmly planted in my mind.

Shortly afterwards, while I was in Chicago, the Superintendent of the Chicago, Burlington & Quincy Railroad, Mr. A. N. Towne, invited me to inspect what was then considered an ideal passenger train, namely the Aurora Accommodation. I accepted this invitation and while looking over the train, which was fitted with a chain brake, I was introduced by Mr. Towne to Mr. Ambler, the inventor of that brake. The Ambler brake, as was explained to me, consisted of a windlass on the locomotive which could be revolved by pressing a grooved wheel against the flange of the driving-wheel to wind up a chain which extended beneath the entire train over a series of rollers attached to the brake levers of each car and so arranged that the tightening of the chain caused the brake-levers to move and thereby apply the brake shoes to the wheels. I ventured to say to Mr. Ambler that I had been working upon a brake myself, but was immediately informed by him that there was no use working upon the brake problem, because he had devised the only feasible plan, which was fully protected by patents. Mr. Ambler's opinion and advice, however, proved to be an incentive to a more energetic pursuit of the subject.

As an improvement on Mr. Ambler's plan, I considered the use of a long cylinder to be placed under the locomotive, the piston of this cylinder to be so connected to the chain that it could be drawn tight by the application of steam from the locomotive boiler with a force which could be more accurately controlled than was possible with the windlass arrangement. A short study of this idea showed that it would be impossible to have a cylinder long enough to operate a chain brake upon more than four or five cars, whereas trains of ten and twelve passenger cars were frequently run upon the important railways.

My next thought was the placing of a steam cylinder under each car with a pipe connection extended from the locomotive beneath its tender and under each car, with flexible connections of some sort not then thought out, so that steam could be transmitted from the locomotive through the train pipe to all of the cylinders; but, as in the case of the attempt to improve the chain brake, it required but little time with some experimentation to disclose the fact that it would be impossible, even in warm weather, to successfully work the brakes upon a number of cars by means of steam transmitted from the locomotive boiler through pipes to brake cylinders.

Shortly after I had reached this conclusion, I was induced by a couple of young women who came into my father's works to subscribe for a monthly paper, and in a very early number, probably the first one I received, there was an account of the tunneling of Mount Cenis by machinery driven by compressed air conveyed through 3000 ft. of pipes, the then depth of that tunnel. This account of the use of compressed air instantly indicated that brake apparatus of the kind contemplated for operation by steam could be operated by means of compressed air upon any length of train, and I thereupon began actively to develop drawings of apparatus suitable for the purpose and in 1867 promptly filed a caveat in the United States Patent Office to protect the invention. In the meantime, I had removed from Schenectady to Pittsburgh, where I met Mr. Ralph Baggaley, who undertook to defray the cost of constructing the apparatus needed to make a demonstration.

At that time no compressed-air apparatus of importance had within my knowledge been put in operation. The apparatus needed for a demonstration was, however, laboriously constructed in a machine shop in Pittsburgh, being finally completed in the summer or early autumn of 1868. This apparatus consisted of an air pump, a main reservoir into which air was to be compressed for the locomo-

tive equipment, and four or five cylinders such as were to be put under the cars, with the necessary piping, all so arranged that their operation as upon a train could be observed. Railway officials of the Pennsylvania and Panhandle railroads were then invited to inspect the apparatus and witness its operation. As a result, the Superintendent of what was then known as the Panhandle Railroad, Mr. W. W. Card, offered to put the Steubenville accommodation train at my disposal to enable me to make a practical demonstration. The apparatus exhibited was removed from the shop and applied to this train, which consisted of a locomotive and four cars. Upon its first run after the apparatus was attached to the train, the engineer, Daniel Tate, on emerging from the tunnel near the Union Station in Pittsburgh, saw a horse and wagon standing upon the track. The instantaneous application of the air brakes prevented what might have been a serious accident, and the value of this invention was thus quickly proven and the air brake started upon a most useful and successful career.

Prior to the construction and practical test of the air brake, I had opportunities while traveling to present the subject to numerous railway officials and to endeavor to secure their coöperation in the development of the apparatus. None of those approached appeared to have faith in the idea, though I afterwards found that the acquaintances made and the many discussions I had had with railway people were of great advantage in the introduction of the air brake upon the railways with which they were connected.

I suppose many persons present have heard or read the story of an alleged interview between Commodore Vanderbilt and myself about the application of air brakes to the New York Central. The story as told seems to have appealed to the imagination of many people. As a matter of fact, there is no foundation whatever for that story. From the moment when the practicability of air brakes was demonstrated to the present hour, there has been nothing but satisfaction and pleasure in being associated with an invention which has contributed so much to the safety and comfort of travelers and so greatly to the prosperity of railways.

In the development and introduction of the air brake, I was controlled by the apparent fact that the apparatus would have to be uniform upon all cars to provide for the convenient change of the composition of trains. It also was most obvious, in view of the crying demand for some better means for stopping trains, that some power brake would inevitably be universally applied to all of the cars

and engines upon all railways. These ideas naturally involved a further one, namely, the importance of having all of the brake apparatus made by one company, so as to insure absolute uniformity and consequent interchangeability, and this led to the formation of the Westinghouse Air Brake Company early in 1869.

The essential parts of the air brake as first applied were:

a An air-pump driven by a steam engine receiving its supply from the boiler of the locomotive

b A main reservoir on the locomotive into which air was compressed to about 60 or 70 lb. pressure per sq. in.

c A pipe leading from the reservoir to a valve mechanism convenient to the engineer

d Brake cylinders for the tender and each car

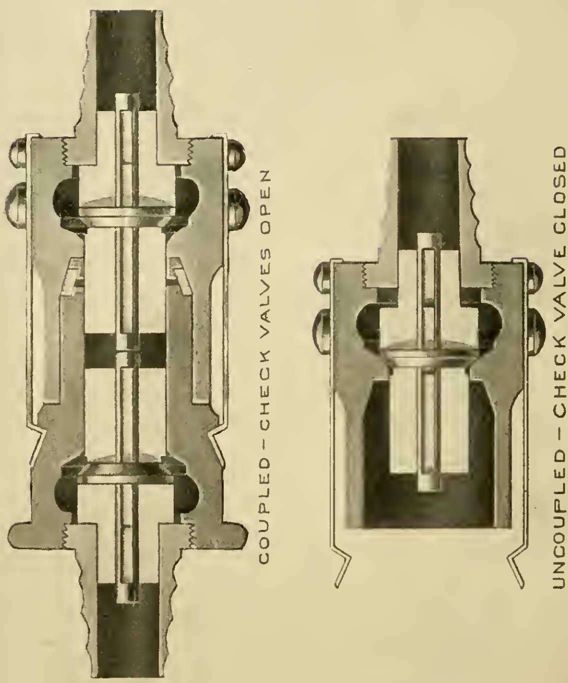
e A line of pipe leading from the brake valve under the tender and all of the cars, with a pipe connection to each brake cylinder

f Flexible hose connections between the cars provided with couplings having valves which were automatically opened when the two parts of the couplings were joined and automatically closed when the couplings were separated so that the valve of the coupling at the end of the train was always closed and prevented the escape of air when introduced into the brake pipe

The piston of each cylinder was attached to the ordinary hand-brake lever in such a manner that when the piston was thrust outward by the admission of compressed air, the brakes were applied. When the engineer had occasion to stop his train, he admitted the air from the reservoir on the locomotive into the brake cylinders through the train pipe. The pistons of all cylinders were, it was then supposed, simultaneously moved to set all of the brakes with a force depending upon the amount of air admitted through the valve under the control of the engineer.

To release the brakes, the handle of the brake valve was moved so as to cut off communication with the reservoir and then to open a passage from the brake pipe to the atmosphere, permitting the air which had been admitted to the pipes and cylinders to escape.

The success of the apparatus upon the first train was followed by an application of an equipment to a train of six cars on the Pennsylvania Railroad, and in September 1869, this train was placed at the disposal of the Association of Master Mechanics representing numerous railways, which association was then in session at Pittsburgh.



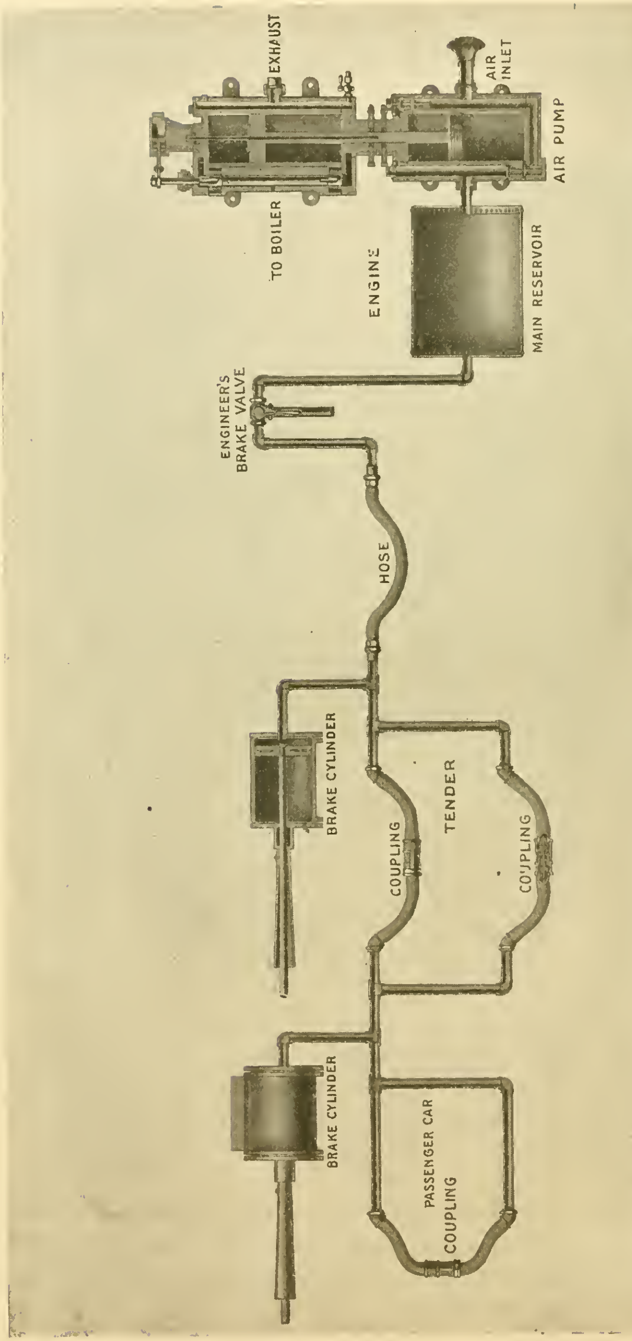
FIRST FORM OF HOSE COUPLING WITH CHECK VALVES.
AS USED WITH THE STRAIGHT AIR BRAKE OF 1869.

The train was run to Altoona and the air brakes were used exclusively for controlling the speed of the train on the eastern slope of the Alleghenies, and special stops were made at the steepest portions of the line in such an incredably short distance (as we all thought then) as to establish firmly in the minds of all present the fact that trains could be efficiently and successfully controlled by means of brakes operated by compressed air.

The next event of importance was the application of the brakes in November 1869, to a longer train of ten cars upon the Pennsylvania Railroad, which was taken to Philadelphia for the purpose of demonstrating to the directors of that railway the success of the apparatus. I may say at this point that the Pennsylvania Railroad had been using for some years a chain brake similar to the one applied by Mr. Ambler, but had found that its use was limited to short trains and that it was not a satisfactory contrivance for the purpose intended. There were invited to witness these trials in Philadelphia a large number of railway people and the papers gave extended notices of the tests made, which brought to the train on the next day Mr. George L. Dunlop, the General Superintendent of the Chicago & North Western Railway, who was desirous of having the whole apparatus fully explained to him. The result of his inspection of the air-brake apparatus was an invitation to make a demonstration upon his railway in Chicago, and he offered, if the Pennsylvania Railroad would send a train for the purpose, to invite the leading railway people and members of the press of that vicinity. The apparatus was then transferred to a train consisting of a new locomotive and six new cars, and this train was run to Chicago over the Ft. Wayne Railroad, and a number of tests were immediately afterwards made upon the tracks of the Chicago & North Western Railway, evidently to the entire satisfaction of those present. From Chicago, the train proceeded to Indianapolis, where other tests were made, and then back to Pittsburgh.

The outcome of these demonstrations was immediate orders for equipment for the Michigan Central and the Chicago & North Western, and shortly after for the Union Pacific Railway in the West and for the Old Colony and the Boston & Providence roads in the East.

I refer to these details to illustrate the readiness with which railway officials took up this invention and the comparative ease with which the required orders were secured, and because it has been often stated that the trials and tribulations in the introduction of the brake were of the severest nature.



THE "WESTINGHOUSE" SYSTEM NON-AUTOMATIC AIR BRAKE, 1869. COMMONLY KNOWN AS THE "STRAIGHT AIR" BRAKE.

Works were built in Pittsburgh for the manufacture of the apparatus and were fitted with the best tools obtainable. Standards were adopted and adhered to in the parts of the apparatus which required uniformity in construction in order to insure interchange of the rolling stock so fitted upon various roads. I think I am safe in saying that the course pursued in the manufacture and introduction of the brake had a more important bearing than anything else in deciding the Railway Master Mechanics and Master Car Builders a few years later to take up the question of the standardization of various parts of cars in order that repairs could be more conveniently made.

It soon developed that it took considerable time to apply the brakes with full force and a longer time to release them, and that in the event of a break-in-two of a train (a frequent occurrence in those days) the rear section would be uncontrolled, and when this occurred upon an ascending gradient, the rear detached section might run away with disastrous results. To overcome this difficulty a new development was necessary, the outcome of which was what has since been known as the automatic air brake.

In the automatic air brake equipment there were the same air-pump, reservoir, train pipe and brake cylinder, but in addition to these there were two important features added to the tender and each car equipment; the first, an auxiliary reservoir, and the second, a triple valve or device interposed between the brake pipe, brake cylinder and auxiliary reservoir. This triple valve was so constructed that when air was admitted to the train pipe, an opening was established between the train pipe and the auxiliary reservoir whereby the train pipe and the reservoir were filled with air under pressure. The valve also opened a passage from the brake cylinder to the atmosphere. This was the normal condition of the apparatus when the brakes were off. To apply the brakes, the engineer discharged a portion of the air from the train pipe, whereupon the triple valve closed the connection between the brake pipe and the reservoir and between the brake cylinder and the atmosphere and then opened a passage from the auxiliary reservoir to the brake cylinder, the piston of which was moved outwardly by the air from the auxiliary reservoir so as to apply the brakes. The restoration of the pressure within the brake pipe released the brakes and recharged the reservoir. This development occurred during 1872 and 1873.

The automatic brake was at that time supposed to be instantaneous in its action in applying the brakes, and almost instantaneous in releasing them. In the event of the escape of air from the train pipe

by its rupture or by the separation of the train, the air stored in the auxiliary reservoirs instantly and automatically applied the brakes to all parts of the train and they could be released only by repairing the damage and restoring the pressure, or by means of special release valves operated by the train men.

The automatic brake having proved itself vastly superior to the plain or straight air brake first described, it soon became a standard but during the transition period an automatic brake was easily converted into a plain brake by a manually operated special valve arranged in the casing of the triple valve.

The gradual increase in the length of freight trains and the numerous accidents due to lack of brake control early suggested that automatic air brakes should be made a part of the equipment of all freight trains and to determine the practicability of the automatic brake for this purpose a train of fifty cars was fitted in the early '80s and taken over the Alleghenies on the Pennsylvania Railroad, and the tests made demonstrated that such a train could be controlled on the heaviest gradients by this means.

In 1885 the Master Car Builders appointed a committee to report upon the feasibility of the application of brakes to freight trains, and this committee inaugurated what are now known as the Burlington (Ia.) brake trials made in 1886 and 1887. There were presented two trains fitted with air brakes, one fitted with a vacuum brake and one with the brake operated by means of attachments to the drawbars similar to the conception first referred to. Each of these trains had fifty cars. These tests proved the inadequacy of the type of automatic air brake then presented by the Westinghouse Air Brake Company, as well as the inadequacy of all the other brakes then tested.

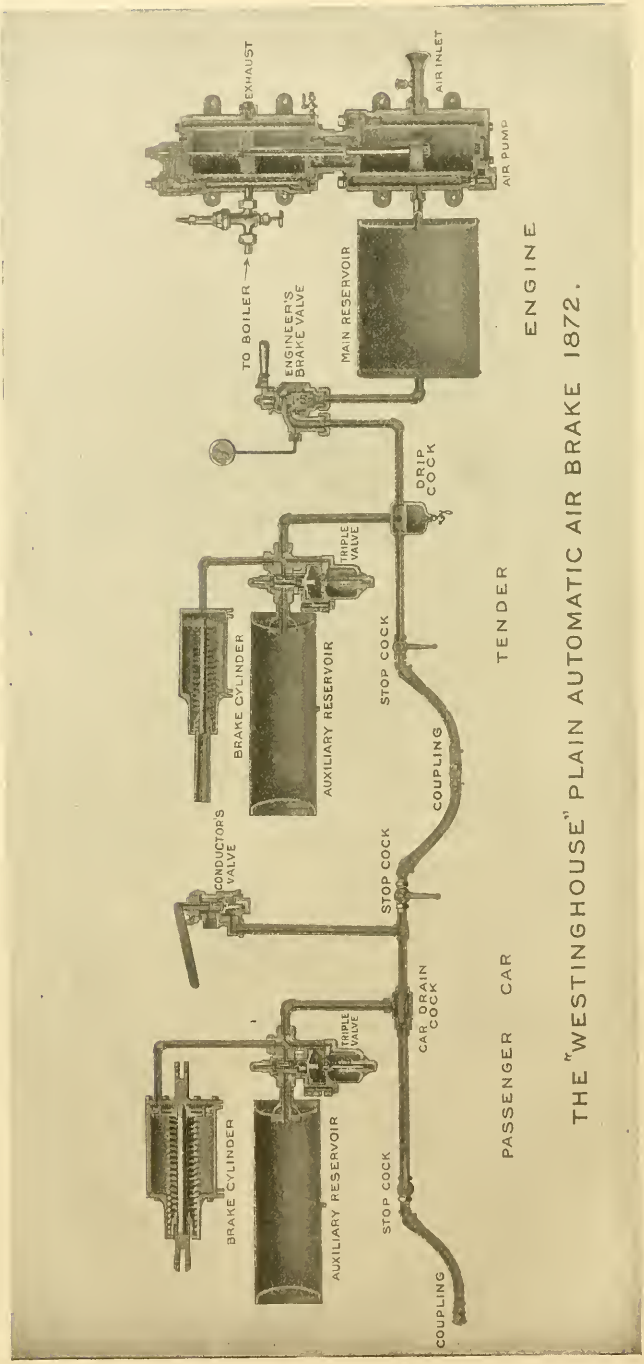
It becoming apparent that the lack of success at Burlington was due to the comparatively slow application of the brakes upon the rear portion of the train, the effect of which was to cause most serious shocks almost like collisions, a new development was imperatively needed in order to insure the successful handling of freight trains of fifty cars.

As a part of the automatic air-brake passenger equipment, I had developed in the '70s a system of train signalling involving the use of a second train pipe, which is now in general use upon all of the railways. This signalling apparatus had a sensitive valve device connected to a small reservoir upon the locomotive and these were so arranged that when compressed air was admitted through a small opening into the signalling pipe, both the pipe and reservoir were

charged to a low pressure (at the present time to 45 lb.). By opening a valve at any point in the train to permit a small quantity of air to escape from the signal pipe, the delicate valve referred to was caused to move so as to admit air from its auxiliary reservoir to blow a whistle located in the cab of the locomotive. It was found upon experimentation that when the valve in any car remote from the engine was quickly opened and closed as many as five times, the whistle would be blown an equal number of times, the first time being after the last escape of air; that is to say, there were set in motion five distinct waves of air each capable of doing work.

During these developments it was found that the waves of air within the brake pipe traveled as rapidly as sound, i.e., about 1100 feet a second.

Being fully impressed with the idea that if the wave of air which was utilized for signalling could be made to operate the triple valves upon the cars, there would then be an almost instantaneous application of the brakes upon the front, rear and other portions of the train, this idea, with hard work and a large number of experiments, shortly produced what is now known as the quick-action automatic brake. The Westinghouse train was left at Burlington in order that the new triple valves with the quick action attachment could be applied and further experiments made. The valves as developed for this emergency proved to be successful and the tests made with this train after their application were eminently satisfactory to the railway officials. It was thereupon arranged to take this train to Minneapolis and St. Paul, Milwaukee, Chicago, St. Louis, Cincinnati, New York, Albany, through to Boston and New England, to Washington, and then to Pittsburgh, innumerable demonstrations being made during this journey of some thousands of miles. This train, drawn by two locomotives, was frequently run at speeds above fifty miles an hour and the tests were witnessed by all of the prominent railroad people of the country. So great was the demand for good brakes on freight trains that considerable difficulty was at first experienced in promptly filling the orders of railway companies. Nevertheless, the wide publicity given to these tests, coupled with a public demand for the adoption of means to prevent accidents, brought about the enactment of a law by the Congress obliging the railways to apply brakes and also automatic couplers to all freight trains in the United States within a time named in the Act, which time was subsequently extended because it was physically impossible for the railway companies to make the introduction within the time first prescribed.



THE "WESTINGHOUSE" PLAIN AUTOMATIC AIR BRAKE 1872.

The quick-action automatic brake was operated like the first automatic brake for ordinary train movements; the quick action resulted only when it was necessary to apply the brakes for an emergency.

No sooner had the quick-action automatic brake been developed to operate successfully on trains of fifty cars than new conditions were presented. Steel freight cars carrying enormous loads had in the meantime been developed and freight locomotives had been increased in capacity, so that trains were often composed of 70 to 80 cars and more recently some trains have had as high as 100 cars. This possibility had, however, been foreseen and experiments were constantly being carried on so to improve the apparatus, that it could be used to control trains of any practical length; and these experiments also had in view the more nearly instantaneous action of the brakes for ordinary service purposes than was possible with the automatic brake or with the quick action brake. The result was a most important development.

The present improved triple valve has the emergency feature, but it also has what is known as the quick-service application feature; that is, for ordinary purposes the air is admitted to all of the brake cylinders so quickly that the longest freight train can be handled with almost the precision obtainable in the control of passenger trains of from six to twelve cars.

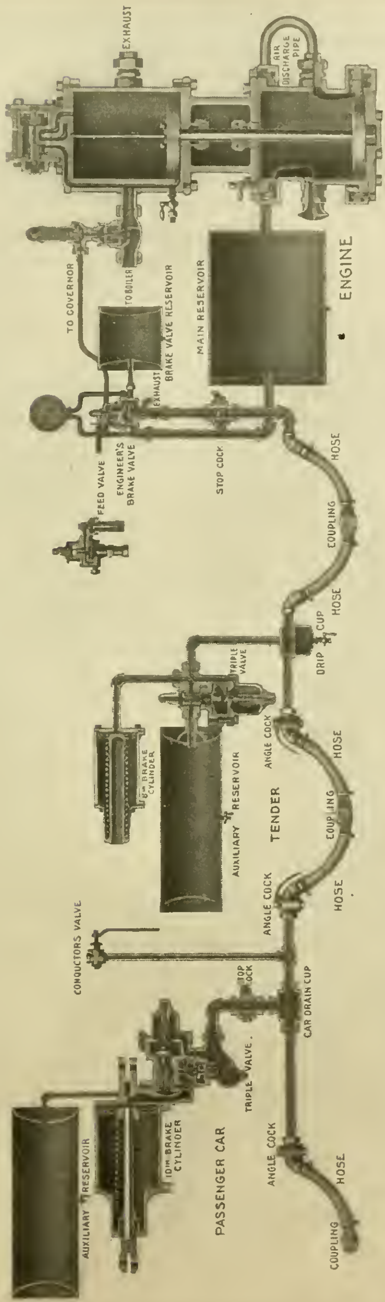
In the matter of the development of the brakes for operation upon passenger trains, nothing that skill and perseverance could suggest has been omitted in securing the highest degree of perfection. The requirements during the past few years, by reason of the greater weight of cars and locomotives and of the higher speeds at which they are run, have necessitated the redesigning of all of the passenger train brake apparatus, including the method of attaching the brake shoes to the cars and the levers and connections for bringing these shoes to bear with the required pressure upon the wheels. For the purpose of insuring the highest efficiency, every wheel of a passenger train, including those under the locomotive, is now acted upon, whereas formerly many of the master mechanics and engineers were apprehensive that it would not be possible to make use of all of the wheels of a locomotive for braking purposes.

During the past twelve months, most elaborate tests of the latest form of apparatus for passenger service have been carried out under the direction of officials of several railways and of the Westinghouse Air Brake Company, in order to prove the operativeness of the new constructions and their capability to insure the highest degree of efficiency.

From the very beginning of its operations, the Brake Company has maintained a strong staff of experienced engineers, some of whom are located in each of the large railway centers and whose services are always at the command of the railways. It is the duty of one or more of these trained men to proceed to the scene of any accident that may have occurred in order to ascertain the cause, to report thereon and to render such aid and coöperation to the railway officials as will tend to avoid a like accident if in any manner the brake can contribute to that end.

The Air Brake Company has always had in its works, for experimental purposes, sets of brake cylinders, pipes and couplings, representing the apparatus upon trains of various lengths, so that tests and demonstrations could be readily made for all sorts of purposes, including the educating or informing of railway officials who came to seek information. To spread this information more effectively, the company about fifteen years ago constructed and equipped a special instruction car in which were arranged 50 sets of brake cylinders and pipes equivalent to like apparatus upon a freight train. This car was provided with a boiler to drive the air-pump for the production of the air under pressure needed to operate the brakes. Operative models of all parts of the apparatus were shown in section so that their construction and operation could be more quickly comprehended. This car, in charge of experienced instructors, was moved from place to place, and engineers, firemen, conductors, and other train employees in general visited it to familiarize themselves not only with the operation of the brake but with its construction, and in this manner there has been developed throughout the country a knowledge of the air-brake art which has proved of inestimable value to the railway corporations and their patrons. The records of the Westinghouse Air Brake Company show that to December 1, 1910, their instruction car had travelled over 113,000 miles. Numerous railways have also provided their own instruction cars, so that it may be safely said that every railway employee having anything to do with the operation of trains, freight or passenger, has been required to familiarize himself with the working of the brakes and so to study the subject that he could pass an examination, 280,258 employees having so far been examined by representatives of the Westinghouse Air Brake Company, and in numerous cases these men have been required to show sufficient knowledge of the brake to entitle them to receive certificates of their proficiency.

The importance of the maintenance of the brake to railways has



THE "WESTINGHOUSE" SYSTEM QUICK ACTION AUTOMATIC BRAKE 1887.

not been overlooked by railway officials. They have appointed superintendents of brakes and numerous inspectors, and there is an association of air-brake officials, organized in 1893 and now having 1015 members, who meet annually in convention to discuss thoroughly the questions which are constantly arising, so that today there exists an organization of which scarcely any of the public has ever heard—an organization which is constantly devoting skill and energy to the care of apparatus which above everything else in connection with railways contributes to the safe transportation of passengers and freight.

I have often been asked how many lives have been saved by the use of the air brake and I have as often said it might well be a great many thousand, but that it was impossible to make even an approximate estimate. At a banquet given in Washington to the members of the International Railway Congress in May 1905, a diplomat, in speaking on the subject of the importance of railway brakes, said he felt safe in saying the air brake had saved more lives than any general had ever lost in a great battle.

I have spoken of four chief developments. It has been necessary, in order to avoid disastrous consequences, that each development should be of such a kind that cars fitted with newer apparatus could operate with little inconvenience with cars fitted with earlier apparatus. As it stands today scarcely any of the old type of brake and the first type of automatic brake are in use, but should a car fitted with the first form of automatic brake be found and put into a train with the more modern apparatus, such older apparatus would be found to operate fairly well with the more perfect form. The prevailing idea in the development and introduction of the brake has therefore been an adherence to such uniformity of apparatus that the interchange of traffic over various roads could go on uninterruptedly.

There is probably no apparatus in use today which has received such thoughtful consideration and been the object of such care in every one of its details as what is now popularly known as the air brake, and which is in universal use in the United States and in many other countries of the world.

In my estimation, there could be no better illustration of the value of the maintenance of standards than has been given by the manufacture and introduction of air brakes upon railways, for without such standards, train brakes would not have come into general use, with consequences which railway officials and the public can well appreciate.

My story would be incomplete without a reference to the splendid assistance which the railways of this and many other countries have rendered. They have been lavish in providing those facilities for making the thousands of tests which were necessary to progress in the developments I have recited; to the Pennsylvania Railroad especially, upon which the most important experiments were first made, the other railways of the country, as well as the traveling public, owe a debt of gratitude. When a railway (as did the Southern Pacific two years ago) provides a new train of one hundred steel cars to be fitted with the newer form of automatic brake, in order to carry on, with a staff of skilled men under the direction of the chief officers of the company, a series of experiments upon its heaviest gradients, requiring several weeks, for the purpose of securing greater safety and an increased carrying capacity per train, with the consequent lessening of the cost of transportation, it is just that the managers of such a corporation should receive credit for their farsighted policy. To name the railways and merely to state chronologically the tests of brakes which have been made during forty years would require several volumes.

It only remains for me to say that I am extremely gratified by the patience and attention with which you have listened to the reading of this address, and I am amply repaid if what I have said has been illustrative and interesting to you.

THE MECHANICAL HANDLING OF FREIGHT

By Samuel B. Fowler

ABSTRACT OF PAPER

Lack of adequate terminal facilities, increase of net income and lower freight rates present problems the solutions of which are vital to the transportation company, shipper and consignee alike. Additional facilities are difficult to obtain, since there is usually no available land adjacent to the terminal or it is held at a prohibitive price. The capacity of present terminals can be increased by handling larger unit loads and moving them at greater speed, as well as by increasing the floor area by the use of freight sheds of more than one story. This is made possible by the substitution of mechanical devices for manual labor and hand trucks.

The terminal handling cost is a large item in freight charges. Mechanical handling methods will reduce the total transportation cost sufficiently to permit of a material gain in income, a decrease in rates, or possibly both.

The use of machinery will also bring about a new type of terminals and a revolution in present terminal methods, making possible other important economies. These economies are possible with team freight as well as l.c.l. freight, and with water-borne traffic as well as rail-borne traffic.

The problems thus presented should be worked out with a mind free from the bias caused by long familiarity with present practices.

THE MECHANICAL HANDLING OF FREIGHT

By S. B. Fowler, Boston, Mass.

Non-Member

The usual discussion of this subject has dealt almost entirely with the merits of mechanical versus manual handling of freight as viewed from the point of saving in costs, principally in relation to the present type of terminal and freight shed.

2 Further consideration of the problem shows that it has a far reaching effect on the whole transportation question and a full discussion of the subject cannot fail to bring out its direct or indirect bearing on every phase of the freight transportation problem. Its application has a direct and important bearing on the costs of transportation and even a more direct effect on the efficiency of the transportation system as a whole.

EFFECT OF TERMINALS ON TRANSPORTATION

3 I wish at the beginning to emphasize this feature of the subject and to make it plain that the object aimed at is not wholly the reduction in the cost of handling goods at freight stations, although that is a result well worth accomplishing, but to show as well the possibilities in increasing the general efficiency of transportation.

4 It must be admitted that there is a widespread demand, on the part of the public at least, for a decrease in freight charges and improvement in the efficiency of the service, the need for which is also recognized by the transportation companies themselves.

5 In a paper by James J. Hill, chairman of the board of directors of the Great Northern Railroad, presented last June before the National Association of Millers, the inefficiency of the country's transportation service is strongly emphasized and is emphatically stated to be due to inadequate terminal facilities. He also states

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

that the pressure upon existing terminals is a present menace and a future handicap; that the problem of terminals is the greatest problem of the country and that if neglected for the next five years as it has been during the last ten the results will be disastrous.

6 That a reduction in the cost of terminal freight handling will make possible a material reduction in rates, a material increase in the net income to the transportation companies or perhaps a combination of both can be easily shown. It is almost wholly a terminal problem. This is, in fact, so far considered to be true that the following have become recognized axioms: (*a*) the efficiency of a transportation system is limited, not by its carrying capacity, but by its terminal facilities; (*b*) the essential factor in transportation costs is not the cost of hauling the goods, but the expense of handling at terminal stations.

7 It is obvious that there can be no improvement either in the efficiency of the service or in its carrying capacity by the mere addition of more trains when the present inefficiency is due to con gestion in yards and terminals. I do not understand that it is contended by anyone that the actual capacity to haul goods has been anywhere near reached. In the last few years immense sums of money have been expended in straightening out curves, cutting down grades and in other ways adapting the permanent way for the use of larger cars and more powerful locomotives, until a point has been reached where any further reduction in the cost of transporting freight is of no material importance. In water transportation there has been the same increase in carrying capacities and motive powers and any further reduction in transportation costs must be brought about by a decrease in the terminal expenses.

8 That this fact may be appreciated let us take as an example the item of miscellaneous package freight, known in railroad practice as L.C.L. freight; and as I shall occasionally use certain statistics let me say a word now regarding them.

9 It is well recognized that statistics of transportation costs are to a certain degree unsatisfactory and more or less unreliable when it comes to comparisons. This is due largely to the lack of uniformity in methods employed in arriving at results as well as to a variance in practice as to what items are included in calculating a given cost. In the selection of any figures used, only conservative ones have been taken and those given by reliable authorities.

10 The actual cost of transporting freight by rail can safely be stated as 3 milis per ton-mile, which includes the operating expense

and interest on rolling stock and permanent way investment. This figure is for the average freight traffic; bulk freight, such as ore or coal, can be hauled for less.

11 A careful study of the published costs of handling L.C.L. freight at terminals seems to warrant, as a conservative estimated cost, 40 cents per ton for outbound and 35 cents per ton for inbound freight, a total terminal charge of 75 cents on each ton. That the cost of transportation may equal the terminal cost, this ton of freight must be hauled 250 miles; but the average ton-haul is only 135 miles.

12 The cost of hauling this distance is 40 cents; added to the terminal expenses of 75 cents, the total cost of transporting one ton the average haul is \$1.15, 65 per cent of which is therefore terminal expense. It is estimated that in terminals provided with machinery for freight handling the terminal cost can be reduced at least to about one-quarter of its present expense, or to 19 cents per ton.

13 The total transportation cost would then amount to 59 cents per ton, a decrease in total cost of practically 50 per cent.

14 I believe, it is perfectly plain that the problem before us is one of terminals only. It is an engineering problem along the broadest lines.

15 It is not a problem of designing a machine or a system of machines adapted to the transference of goods between freight sheds and cars or vessels, but rather the adaptation of well-known devices to this work; not the simple adaptation of machinery to the transportation of merchandise, but a study of the effects of such adaptation on methods to be employed at terminals in the future; not the introduction of machinery in the present type of terminal, but rather the designing of an entirely new style of terminal adapted to the use of machinery.

16 Not long ago the cost of loading ore at the ports on the Great Lakes was 35 cents per ton; it now costs less than 2 cents per ton. This has been accomplished by the use of machinery in loading and by the design of a different type of terminal, adapted to the use of this specially designed machinery.

17 In considering the transportation terminal problem we have to deal with two distinct types of terminals, one for rail-borne freight, one for water-borne freight. The inefficiency of each method of transportation is the same, that of inadequate terminal facilities. We will discuss each problem separately, bearing in mind, however, that much of the general discussion of one type relates directly to the other.

SOLUTION OF THE TERMINAL PROBLEM

18 The solution of the terminal problem resolves itself into two factors, the increase in capacity and the reduction of terminal costs.

19 On first thought the natural solution of the first factor is the purchase of more land, thus increasing by as much as is necessary the area required to handle the increasing traffic.

20 Unfortunately the land adjacent to the average terminal has so increased in value that its cost, for terminal uses, is prohibitive; the interest on the required investment would be a greater fixed charge than the traffic would warrant. In addition the necessary increase in area would involve an increase in operating expenses, particularly in the trucking costs, which is the largest item in the handling expense.

21 That the present terminals are worked to their capacity is evident; no additional truckers can be put to work as they are already in each others way, every truck is carrying its capacity in bulk or weight and is moved at its maximum speed, and still the freight is coming in faster than it can be handled. Congestion is the result and congestion means rehandling, which spells additional expense.

22 With these limitations imposed it is evident that to increase the capacity of the terminal we must increase the unit movement; that is, in moving goods to and from the cars, more freight must be taken in each load and this increased load must be moved at greater speed. Manual labor must be eliminated as much as possible, for in no other way can larger loads be handled and at greater speeds.

23 The most feasible method of bringing about these necessary improvements seems to be the substitution of machinery for hand trucks and manual labor, wherever possible. This substitution would in general have the following marked effects on the capacity of a terminal:

a If this machinery were of the overhead type, that portion of the shed floor now necessarily kept free for truck runways would at once be available for the receiving, weighing and sorting of merchandise.

b As the mechanical transporter could carry much greater loads and at much faster speeds, goods would be removed from the receiving floor more rapidly and the capacity for receiving new loads correspondingly increased. For the same reason cars would be unloaded much faster and, as it is practically as cheap to tier goods as to set

them on the floor, the capacity of the inbound shed would be increased accordingly. The cost of tiering by hand is now prohibitive, it being equivalent to a rehandling.

c In mechanical transportation the increase of a few feet in the distance traveled has an immaterial effect on the time or the cost of transportation. The delivering and receiving platform capacity could be practically doubled if both sides of the sheds could be used to receive from or deliver to teams.

d As the time consumed and the cost of hoisting or lowering a few additional feet is unimportant, upper floors could be utilized and a large increase in floor area thus obtained.

e Freight-handling machinery could be utilized to assist in the loading and unloading of teams and the time consumed in this operation could be materially reduced.

24 There are equally striking possibilities in reducing the cost of handling freight. The entire cost of handling L.C.L. freight is practically in the labor involved and the wages of truckers is the largest item.

25 A single transporting machine operated by one man should be able to replace at least 16 truckers. The "spotting" of cars, an expensive tedious operation, could be entirely done away with.

26 With a properly designed terminal the shifting of cars from the inbound unloading tracks to the outbound loading tracks could be largely eliminated; it might be possible to approximate closely that ideal condition where the movement of an empty car about the yards becomes unnecessary. Even the partial elimination of these operations would reduce the number of switching engines and crews, and the saving represented by the cost of operation of only one engine and crew is the interest on a considerable investment.

27 Much of the damage to freight for which the transportation companies must eventually pay comes from yard switching and the recoupling of "spotted" cars. Added to this expense is the damage done to the rolling stock itself.

28 Numerous economies could also be brought about in the operations of sorting, weighing and distributing. The full economies that could be effected and the entire possibilities as to increased capacities could not be fully realized without a careful study and discussion of the minute details of the problem; but in a paper of this character we must confine ourselves only to the general details, pointing out the methods applicable and the type of machinery best suited for this service.

COMMENTS ON MODERN INSTALLATIONS

29 The application of machinery to freight handling in railway terminals is of very recent date as is also the interest in such applications. At the Sixth Session of the International Railway Congress held at Paris in September 1900, a committee previously appointed made its report covering practically all the railway systems of the world. The gist of this report was that the use of machinery at freight stations was extremely limited, although in one or two instances the installation of such equipment had been proposed. The only use was that of elevators where stations were of more than one floor, and a limited application of cranes, some hand-operated, some hydraulically and a few electrically.

30 It will be noted that the applications are limited to vertical movement alone, except as to the radius of the crane jib. No recognition is apparent of the need of horizontal movement for the purpose of distribution.

31 Since that time, however, England in particular, has made more or less progress and I believe a brief description of one of the more modern and complete installations will be of interest.

32 This equipment is installed in the North-Eastern Railway Company's warehouse, New Bridge Street, Newcastle. The station contains two floors and a basement; the basement and the first floor being utilized for the regular in- and out-traffic, and the top floor for storage and warehouse purposes. The first floor is provided on the inside with two platforms approximately 300 ft. long and 25 ft. wide, between which is a double line of car tracks. Each platform is served by two overhead traveling cranes of the conventional type of overhead shop cranes, and each can travel the length of the building parallel with the freight car track, except as limited by the position of another crane. Mounted on this traveling crane is a traveling, revolving jib crane having a lifting capacity of one ton. Each of these units is, therefore, provided with four motors, the traveling cross-traversing, revolving and hoisting motor, with a speed at capacity load respectively as follows: 350 ft., 150 ft., 250 ft., and 150 ft. per min. On the outside wall are two revolving jib cranes each equipped with two motors, one for hoisting, the other for revolving, the respective speeds being 60 ft. and 150 ft. per min.

33 The basement has the same arrangement of platforms and tracks, each platform having one crane identical with those of the first floor. There are in addition one car traverser for moving cars

the length of the basement and two car elevators having a lifting capacity of 20 tons and a lowering capacity of 30 tons. Revolving pillar cranes are also installed. A transporter capable of hoisting to the floor level and transporting the length of the building is provided on each side of the building for operation on the top floor.

34 Inside the top floor are six electric hoists operating through hatches from the floor below. There are also the usual number of capstans without which an equipment would be considered incomplete. The maximum lifting capacity of all apparatus except the car elevators is one ton, and the speed of operation of each varies considerably.

35 In an earlier installation where stationary revolving cranes of the hydraulic type were used the horse power per 1000 sq. ft. of platform was 30.3 and the lifting capacity 1.4 tons for the same area. In the later installation just described but 6.13 h.p. for each 1000 sq. ft. of area was needed and a lifting capacity of but 0.27 tons.

36 It will be noted that this installation is defective in two very important respects:

a The horizontal or distributing movement is limited to straight lines and does not cover areas. Those units which have a horizontal movement are limited in action to the platform which they serve and also as to the amount of this platform over which they can travel by the position of the other pieces of apparatus. It is impossible for them to reach any portion of their own platform beyond the other unit.

b All the freight to be handled must be brought to the freight house and all cars to be loaded or unloaded either to the platform inside or outside the freight house, and the range of operation of the freight-handling apparatus confined to the freight station itself.

Such an arrangement of machinery and station buildings has plainly very little effect in increasing the capacity of the terminal, but is principally advantageous in decreasing the costs of loading and unloading at the station platforms. It lacks the flexibility requisite to eliminate the hand truck and is evidently not in the least adapted to handle so-called transfer freight.

37 We are unable to suggest any installation so comprehensive in this country; in fact, we can point to no installation whatever. The United States is, I believe, universally recognized as the leader in the application of labor-saving machinery, but in this particular instance there is an entire absence of it, if we except a few isolated instal-

lations designed for some particular class of merchandise or type of package. This condition applies to all classes of freight, except such bulk freights as coal, grain or ore. The development of special machinery for handling bulk merchandise has been carried to a high degree of perfection although there is a reversion to hand methods at receiving stations where this freight arrives in small units of about a car load.

38 There are a few illustrations of freight-conveying apparatus principally confined to some type of endless belt device, or movable platform; one designed to handle barrels where large shipments of flour form an important part of the traffic; another adapted to convey baggage from the deck of a ship to the pier; still another, a movable platform incorporated in a portable gangway, designed to carry to the pier floor a loaded hand truck, with its stevedore, where the angle of the incline is too steep to permit of his pushing up the truck. An interesting installation is that at the pier of the Old Dominion Steamship Co. at Richmond, Va., where a telpherage system is in operation.

39 All of these equipments are limited not only in capacity, but in scope and serve only straight lines, not areas. In general, the merchandise passing through a railway freight terminal is of three classes: inbound, outbound and transfer freight, the inbound and outbound being further divided into L.C.L. and team freight; the L.C.L. freight passing through the freight sheds, the team freight, as its name implies, being handled in the yards from cars to teams or the reverse.

HANDLING INBOUND AND OUTBOUND FREIGHT

40 The operations in handling outbound freight are about as follows: (*a*) receiving goods from teams; (*b*) checking and receipting for same; (*c*) weighing and classifying; (*d*) sorting for the proper car; (*e*) trucking to the car; and (*f*) stowing in the car. The operation of handling inbound freight, except in the reversal of sequence, is essentially the same with the omission of the weighing, which is not ordinarily done, the weight of the shipping station being accepted.

41 In connection with these enumerated operations certain clerical and record work will be required and hand labor will continue to be a factor to some extent. But the introduction of freight-handling machinery will undoubtedly have an influence on these necessary manual operations, both as to cost and speed of handling.

Space does not permit a discussion of the details involved, but fortunately they do not have a determining influence on our problem.

42 I have already indicated that one way, at least, of increasing the capacity of a railroad terminal is to move freight to and from the cars in greater unit loads and at greater speeds; and that at the same time changes will become possible in the terminal arrangement which will permit a still greater increase in capacity as well as further important economies.

43 A mechanical system for this work must be extremely flexible; it must have both vertical and horizontal movement in the required degree; receive and deliver its loads at any portion of any floor of the freight stations and at any place in the yards to be served; occupy little, if any, space of value for other purposes; and should be simple in operation, not requiring skilled or high-priced labor for its control. The design of the equipment must be such that there must be no interference between machines, and it should be possible to add to the equipment from time to time as required without interfering with the working plant.

44 Consideration of the above requirements points to the suspended or overhead system operated by electric motors. The use of such transporting systems is now very common in industrial plants and a large number of manufacturing companies offer a variety of such appliances. These installations have been highly successful and the mechanical and electrical features of the transporting machines are satisfactorily worked out.

45 The requirements for service in a railway terminal are radically different, however, in many respects. The transporting units in operation will necessarily be far greater in number. Each unit must easily be able to reach and operate over every foot of trackage required to serve all parts of the terminal used for loading and unloading and must be able to do this without interference and without possibility of congestion. The very first effort to apply mechanical transportation of goods between cars and freight sheds or vice versa will prove that the present type of terminal is not suited for the purpose if the maximum results that can be attained are desired.

46 A conventional outbound station having a capacity of 100 cars is operated much as follows: The length of the shed will be such that a string of 20 cars can be accommodated at its side on one of the loading tracks of which there are five. One hundred cars will be placed on these tracks, five rows of 20 each, these cars having been "spotted" so that the doors of the cars abreast of each other will be

opposite one another in order to provide a continuous runway for trucks through the five cars. The opposite side of the house provides the teaming platforms for the reception of loads. The merchandise as received is placed on hand trucks, wheeled to the proper runway and through to the designated car where it is unloaded and stowed away. While the application of transporting machinery is in this case perfectly feasible and larger loads can be carried with greater speed to the designated runway, it is still necessary to push these loads through the cars to the one for which the merchandise is intended. It would evidently be a distinct gain if the transporter could set its load down directly at the proper car door. To accomplish this the loading tracks must be relocated and at least arranged in pairs with island platforms between the pairs. It would be of advantage to move the first loading track far enough from the station platform to allow for teaming space, thus doubling the receiving platform facilities at the shed.

47 The same arrangement is equally applicable to the inbound freight traffic and we thus find ourselves confronted with a rearrangement in which no car is placed at the station platforms for direct loading and unloading. It at once suggests the doing away with the distinction between loading and unloading tracks; the tracks served from the outbound and inbound stations being filled with loaded cars in the morning which will be unloaded into the inbound house and loaded from the outbound house in the same day without the need of switching the empty cars from one house to the other; at the same time the "spotting" and the recoupling being eliminated. The possibility of accomplishing this hinges on the trackage arrangement that can be worked out. The types of transporting machines now in use employ two different kinds of tracks; one type of machine is supported and propelled by single flange wheels so arranged in pairs that the wheels of each pair track on the opposite sides of the web of an I-beam, straddling the beam, as it were, the other type is supported and propelled by wheels having a double flange and running on the top of an ordinary T-rail properly suspended. Each has its advantages as compared with the other, although the true test for selection in any particular case is the cost of installation and future operation.

48 A number of lines of tracks with means of passing from one to the other will be required so that any individual transporter can reach every part of the area indicated. The I-beam type of track will therefore require an installation of permanent trackage erected

over the entire space to be served and must include at the junction points of these various tracks some type of switch included in the track itself. These switches must be controlled by the operator of the transporting machine and should be provided with suitable indicating signals showing the position of the switch as the machine approaches.

49 The T-rail type of track with transporting machine hung from wheels running on top of the rail does not require the use of tongue switches included in the tracks. Each transporter carries with it the switching apparatus which consists, in the main, of an extra set of traveling and propelling wheels that are adapted to engage, when desired, a system of trackage at a different level than that of the main track. These different levels of tracks, which we will designate as loading and unloading tracks, can be moved to any desired location within certain limits as they can be entered from any point of the main track opposite which they happen to be located. The existing conditions at the particular terminal under consideration would of course determine which system of trackage would be the best suited to the individual cases.

ARRANGEMENT OF TRACKS AND TERMINALS

50 The following diagrams are submitted to illustrate only the general idea involved. They show in a general way the application to an inbound freight station provided with six unloading or island platforms, arranged to serve ten lines of cars. Fig. 1 shows the arrangement of overhead tracks where the I-beam type of track is used. One track only being indicated through the freight house. The main track is indicated by the solid line and extends through the shed along one end of the platforms, over the platform farthest from the shed, along the other end of the platforms into the shed, where it connects with the track through it and forms a closed loop. The main track includes all of the switches necessary to divert machines either to or from the tracks serving the other five platforms. This main or loop track is normally continuous, the switches permitting a machine to enter or leave the tracks over the loading platforms being controlled by the operator of the machine. The tracks over the platforms, those requiring the operation of switches to enter or leave are indicated by dotted lines.

51 In unloading the cars the merchandise is broken out and placed on trucks, flatboards or any design of carrier that is best adapted to

the purpose and placed on the platforms ready for moving to the house by any of the machines; the operators of these can see on what platforms loads are waiting as they move along the main track at the entering end of the platforms, and by operation of the switches pass them on to the platform track where loads are ready. They are then

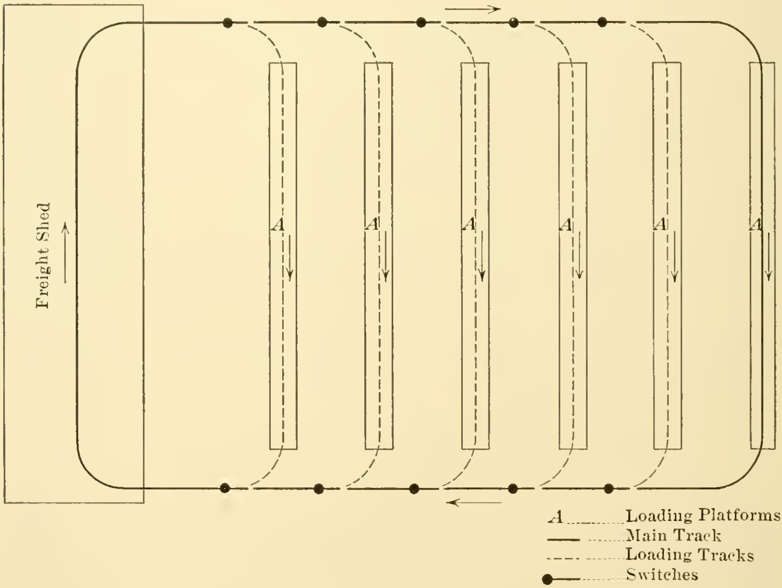


Fig. 1 Arrangement of Overhead Tracks with I-Beam Rails

conveyed to the sheds, deposited at the proper place and the transporter is ready to return to the platforms for another load.

52 If the T-rail type of track is used no switches are required on the main or loop track; the platforms or unloading tracks are at a different level from the main track and are entered by placing the second set of wheels of the transporter in a position to engage the platform track and continue around it, at the same time lifting the main track wheel from engagement with the rail on which they are running. It is, therefore, obvious that unless it is required to unload cars at each platform at the same time, a plainly unnecessary requirement, permanent tracks over each platform are not necessary. It becomes possible in this system to suspend these platform tracks on a traveling crane parallel with the platform, operated either by hand or electric power, and to move it over the platform when it is desired to

unload cars. Under some conditions of operation one such movable platform track would be all that would be required; under other conditions two would be ample to serve the six platforms; or it might be necessary to have tracks becoming permanent at each platform. The same method of switching the transporters to the platform tracks would still be used, thus eliminating track switches.

53 At an outbound station of the same car capacity the same arrangement as already illustrated would be in general adopted, differing, however, in this respect: in loading cars it is necessary to have free access to any of the cars set all of the time, and, therefore, loading tracks must be placed over all platforms. In other words, the essential distinction between the two equipments, is that the required distribution facilities are at a different terminal of the transporting line; in both instances it is at the receiving end of the line, but in the case of outbound freight it is the car end, and in the case of inbound freight it is the freight shed end.

54 In loading goods the distribution is arbitrarily determined by the setting and the designation of the cars to be loaded. The overhead trackage in the freight shed, therefore, can be much as shown in Fig. 1, as the transporter has only to pass through the shed picking up whatever loads, properly assembled, are ready for movement to the designated car. The reverse operation would require a somewhat different arrangement of trackage in the inbound freight shed as the loads coming in require sorting and distribution to prepare them for delivery. Two main line tracks with cross tracks between them, as shown in Fig. 2, would be needed, the number and location being determined by the local requirements and the methods worked out for handling the freight on the house floor.

55 The average distance traversed by the transporter, under the conditions shown in Fig. 1, is the maximum. The addition of another main track parallel to and between those indicated in Fig. 1, will reduce the average haul materially. Addition of loop tracks at certain points will accomplish the same result. The various possible combinations of tracks are too great to attempt even to outline. They vary as much as the present arrangements of terminals themselves. It must be borne in mind, however, that in mechanical transportation up to a certain point, increase in distance traveled has an immaterial effect on the cost or time consumed and that the added expense required to reduce to the minimum the average haul would often be unwarranted.

56 Although we have referred to the inbound and outbound sta-

tions and the overhead trackage associated with them as separate units it is evident that while the freight sheds themselves can be and, under many conditions, should be separate, the trackage over the loading and unloading platforms can be used in common from either shed, and the loading and unloading platform be one and the same. Freight can first be moved from the cars to the inbound shed and then from

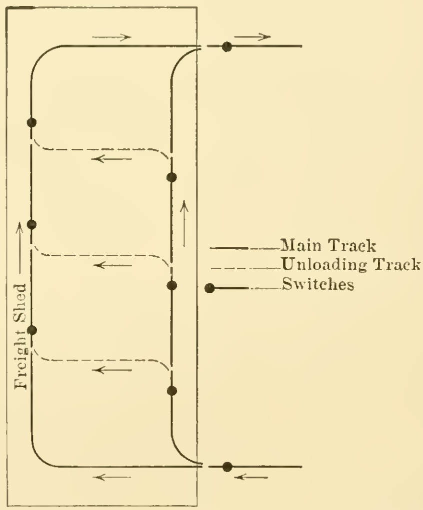


Fig. 2 Arrangement of Overhead Tracks in Freight Shed

the outbound house to the cars for loading; or the two operations can be carried on at the same time. This arrangement makes possible a material reduction in the original investment in overhead trackage and further in the actual number of transporting machines required, as these machines can be utilized for the service of either shed.

57 Freight comes to the outbound house but slowly in the early part of the day; the rush of delivery occurring in the latter portion of the afternoon. This leaves the larger part of the equipment available in the morning for inbound freight and with a sufficient number of transporting machines the entire work of unloading can be accomplished long before the rush period of loading begins.

58 Without taking up in detail the handling of transfer freight at the regular transfer stations, the moving of goods from one car to another, it is plain that the adoption of such a system will effect the same economies in this class of service and in addition reduce the time of car detention at the transfer points.

TYPE AND OPERATION OF CARRIERS

59 In considering the transporting equipment it is evident that the control of each machine must lie in the hands of one man who travels with the machine. Automatic systems are not applicable to this work The operator, in a cab or on a platform, suspended from the traveling motor, controls the starting and stopping of the train, operates the switching devices and depending on the detail adopted may or may not control the hoisting and lowering operations.

60 Because of problems involved in sorting and loading packages for transference, too large a load cannot be put on any one carrier and, therefore, a transporting machine should convey more than one load. For convenience we will consider that on each trip four loads will be carried, although it is entirely possible to draw a larger number. We will assume the transporting device consists of five units, the traversing machine from which is suspended the cab for the operator and four trailers, each equipped with an electric hoist. There are two methods of operation in such a device; the trailers may be considered a permanent part of the device and the control of the hoisting apparatus centered in the cab, or the trailers may be detachable at the will of the operator, magnetic couplers being provided, and the control of each hoist local to the trailer itself.

61 In the case of permanent trailers, the operator not only moves the loads to their proper destination but lowers and raises them as well; where detachable trailers are used the function of the operator is simply to move empty or loaded trailers. This requires a main or traveling track always clear for continuous movement, and shunt tracks for the trailers must be provided where the operator can leave them or from which he can pick them up. The raising or lowering of the loads is then controlled by the men who handle the freight at the car or on the shed floor. The balance of the equipment required consists of the carriers attached to the trailer hoists.

62 The kind of merchandise handled at any given terminal would determine the type of carrier best adapted. It may be a simple flatboard or a wheel truck and each can be provided with detachable or hinged sides if necessary. In the case of special packages, as bales of wool or cotton for an illustration, neither flatboard nor truck would be required. Any type of carrier required at a certain terminal, can be readily designed and all so made that they are interchangeable and attachable to the hooks of the hoists.

63 In thus transporting merchandise the solution evidently does

not lie in excessive loads or abnormal speeds, but rather in a moderate limit as to both. As both the feet and the load must be hoisted and the distances traveled are comparatively small, the time required to reach maximum speed must be short. Small loads on each hoist and a total load on the transporting motor small enough to admit of rapid acceleration and quick stopping are necessary. Let us assume that the average load on each hoist will be 500 lb. and the average load on each machine one ton; the capacity of each motor being double that of this normal load to allow for variation in load. The average load of a hand truck will be less than 250 lb. and the speed of movement will average about 125 ft. per min. With an average load of 500 lb. per carrier the total load carried will be 2000 lb.; at least eight times as much as the hand truck will move each trip. The hoisting speed can be practically anywhere from 60 to 120 ft. per min. and the conveying speed anywhere up to 1000 ft. per min. That we may not overestimate in our calculation, allowing for curves, delays at switches, etc., we will limit the estimated speed to 250 ft. per min., a speed of less than 3 mi. per hr. This is, as will be admitted by everyone, an extremely conservative estimate, yet it makes it possible for one man with the transporter to accomplish the work of 16 men in the same period of time. It will be seen that the preceding is a ridiculously conservative estimate; that loads can be increased and speed of conveying easily doubled. Considering only these conservative figures it is apparent that the costs of conveying can be reduced in a tremendous degree if one man can replace 16, and the freight-handling capacity of a given floor space can be doubled if the goods can be moved twice as fast from it or to it.

OPERATIONS INVOLVED IN HANDLING MERCHANDISE

64 The various operations involved in the receiving of merchandise either at the inbound or the outbound house and preparing it for delivery to the consignee or to the car we can consider only in the most superificial way. Freight delivered to the outbound house arrives in packages of varying weights and sizes, and anything from a full load of one kind of goods consigned to a single destination to a load in which there are as many classifications and destinations as there are packages.

65 In many cases it is possible to have the packages piled on flatboards, to be instantly removed from the teams by the transporting machines. This would mean a great reduction in the time a team

would have to stand at the platform, a direct saving in trucking expense to the shipper, a relief to the team congestion at platforms and an increase of the platform receiving capacity.

66 Where deliveries for one destination are sufficient in amount to constitute an average trailer load all manual handling can be entirely eliminated as the transporting machine can remove the goods direct from the team, run the load over a scale included in the overhead track and then move it to the proper car for loading. Where a delivery is a load of various packages for different destinations, the packages must of course be sorted and handled separately. Machinery can unload these from the team as well, but must then leave them for weighing, sorting, etc.

67 It seems probable that it would be advantageous to have a freight house so arranged that a certain portion of it is assigned for the handling of each of these classes of freight deliveries. While there is a multitude of variations in types of loads between the two extreme types mentioned, it would not be difficult to determine into what division of the freight shed the load should go, the distinction between loads being the amount of classification and sorting required. A practical freight house arrangement would be to have two floors, the ground floor for the loads requiring the least, the upper floor for the loads requiring the most handling. In this way the drivers of teams can go to the platforms at any vacant space the railroad employees classifying the load and the goods taken to the proper floor. It is probable that the floor for handling the miscellaneous freight could be provided with special machinery for sorting according to destination. Some of the appliances could probably be of an automatic type and hand trucking practically eliminated.

68 A similar method of handling inbound freight could be adopted and its operation facilitated, since in unloading cars a more intelligent arrangement of loads for the different station floors could be made than could be expected in the case of team delivery.

69 Thus far we have been considering only L. C. L. freight. It is by far the most expensive to handle and comprises about 40 per cent of the total freight handled. It is, however, the freight for which additional terminal capacity is badly needed.

70 The balance of the freight with which we are concerned is the team-track freight, goods which are handled in car-load lots and delivered to or removed from the car floors direct by teams. The cost to the railroad in loading or unloading this class of freight is comparatively small, about five cents per ton. In spite of this low cost the

application of machinery to handle this merchandise would prove of value. Some of this freight is of great bulk and weight and much time and labor is required to load and unload it. Special overhead tracks, capable of carrying heavy loads, can be used for this service and transporting machines and hoists of large capacity provided. Any device that will hasten the work at the team tracks will not only reduce the costs but the car detention as well. This car detention is an important matter as shown by the daily earning capacity ($3 per day) a car is quoted as having.

REDUCTION IN HANDLING COSTS

71 A fair estimate of the average load of a car is 45,000 lb., $22\frac{1}{2}$ tons. The cost of handling this freight on the team tracks is now five cents per ton, $\$1.12\frac{1}{2}$ per car. If inbound L. C. L. freight can be unloaded for ten cents per ton, and we believe it can, it would cost the railroad only $\$1.12\frac{1}{2}$ more per car to handle much of the present team freight through the freight sheds as in the case of L.C.L. freight. This car could then be unloaded and reloaded in a day, a saving at least of one day, as two days are usually allowed for unloading before demurrage is charged, a direct saving to the railroad company of $\$1.87\frac{1}{2}$ on each car so handled, and a storage charge can be substituted for the demurrage charge. A saving might even be effected on outbound team freight by treating it as house freight for in so handling what possible of the in and outbound team freight much switching, coupling, and uncoupling might be avoided.

72 In discussing the application of machinery to freight handling at railway terminals I have endeavored to make clear that an important reduction in handling costs is possible and that a material increase in the capacity of the present terminals can be provided without the purchase of large amount of adjacent land. I have endeavored to show how these results will have an important effect on the rates and income of the road as well as on its efficiency.

73 The general lines of development toward accomplishing these results have been pointed out and some of the leading reasons for working along these lines have been indicated. Further than this it is impossible to go in this paper. The amount of detail involved in any one phase of the subject will, I believe, be appreciated and it will also be realized that each terminal presents a different problem for solution as any proposed application of machinery must take into consideration in a greater or less degree practically every operation now carried on at the terminal under study.

STEAMSHIP TERMINALS

74 Turning now to steamship or water-borne freight terminals we find the same conditions of too great cost in handling goods, and too little space for the present traffic without even considering the future. The congestion present at a busy pier and the long delays experienced in delivering or receiving shipments is well known. The manager of a large teaming company in New York told me not long ago that a wait of two or three hours at the pier was not unusual and he had known of instances where a team had waited an entire day and at the end came away without its load.

75 The excessive costs of handling freight form an important part of the total costs as in railway transportation. The lack of sufficient capacity for handling the merchandise together with the slowness of manual handling, made slower still by the congestion and consequent rehandling, causes the delay.

76 Speed in loading and unloading vessels is of the greatest importance for differing from railway transporation the vehicle for carrying freight is one large unit, and all goods must wait until the last box is loaded. The motive power also lies idle during this wait. The motive power in railway transportation is in small units, all of which can practically be in use while cars are being loaded. The interest on the large investment represented by a modern steamship, while idle in the dock a day or so, often is an important factor in the profits of a trip. The steamship terminal differs from a railway terminal in that it is necessarily of less area, and a combination terminal as well. Over the same pier floor is handled all classes of inbound, outbound and transfer freight at the same time.

77 In the use of machinery at docks this country is far behind Europe. All large ports of Great Britain and of the Continent are well supplied with cranes of one sort or another; some ordinary pillar cranes, other movable cranes along tracks parallel with the pier. Such apparatus, however, does not constitute a true mechanical freight handling equipment nor does it perform the operations required of such an installation. Its horizontal transporting movement is rather limited and does not reach inside the sheds. The use of hand trucks at these ports is still practiced extensively.

78 It has been the custom recently to attribute the great efficiency of these ports and their lower costs of freight handling to the handling machinery there installed. The cranes principally serve to hoist or to lower loads into the ship's hold, which is done in this country by

the ship's tackle. Unless these goods are taken direct from railway cars or placed at once on cars or teams they must be taken away from or delivered to the cranes by hand trucks.

79 The difference in cost of unloading freight at San Francisco and at Hamburg is only about ten cents per ton, taking the average of all goods handled at Hamburg. San Francisco has practically no machinery and Hamburg an ample supply of modern cranes. Labor is much cheaper at Hamburg, but even this is not the main advantage: 62 per cent of all freight entering the port of Hamburg does not pass over the piers at all. The vessels tie up at moorings in the harbor and transfer their load to so-called Rhine boats, placed alongside, hoisting and lowering with the ship's tackle—the cheapest possible way of transfering merchandise.

80 At the water terminal the methods of loading are practically two in number: (*a*) direct transference to vessel from other water craft, railway cars or teams; (*b*) delivery of goods to pier and later transference to vessel. In this country the second method is generally used, direct transference being practically only from lighters used in a transfer of freight from another terminal. The usual operation, therefore, involves a large amount of handling, and much moving of small loads on trucks. Goods received at the pier are transferred to hand trucks, taken to the scales or else measured, then moved to some predetermined location and removed from trucks to be again loaded and trucked to a point where the ship's hoist can reach the load which is then lowered into the hold. With the substitution of transporting machines much greater loads can be moved from the vehicle delivering and at much greater speeds, taken over track scales and automatically weighed, moving on to the location desired or direct to the ship's hatch and immediately lowered into the hold. The elimination of manual labor is entire except in removing from cars or teams to the carrier and if in the latter case the merchandise is loaded on flatboards placed on the bed of the wagons, even this handling can be done away with.

81 The method of unloading may be either by, (*a*) direct transference to the vehicle which will move it from the pier or dock, or (*b*) direct discharge to the pier and later reloading to boat, railway car or team. In the case of coastwise traffic either method may be adopted. On the other hand cargoes from foreign ports must be handled by the second method because of the custom inspection. The advantages of employing transporting machines in unloading is apparent when contrasted with methods now in use.

82 The planning of overhead trackage for a water terminal is a simpler problem than devising one for a railway terminal, since while it must serve the entire area of the pier shed as in a freight station it need extend outside only far enough to reach the holds of the vessel. Instead of the outside trackage being designed to allow for delivery or reception of goods from a hundred or more points, the only parts necessary to be reached are the hatches of the vessel, few in number. The direct trackage for reaching the hatches must be movable in a line parallel with the pier, and so arranged that they may be entered from any portion of a permanent track forming a loop or a series of intercommunicating loops one side of which is outside of the shed.

83 Steamship freight is generally of larger bulk and greater weight than railroad L.C.L. freight and necessarily heavier trackage and more powerful transporting machines and hoists must be provided. The consignments, however, are usually larger in quantity and much less sorting and classification is necessary, conditions favorable to the maximum elimination of hand labor. Rehandling by manual labor could practically be done away with and if a direct transference between vessels and other transporting vehicles were made possible, the mechanical rehandling could be eliminated, since the transporting machine can hoist the load from the hold, carry it to the car or team and deposit it thereon. If necessary to deposit load on shed floor it can later pick it up without further rehandling and transport it to car or team or to vessel and lower it into the hold. The present cost of loading and unloading could be greatly reduced and the capacity of the terminal increased by the handling of larger unit loads at greater speeds. The capacity could be further increased by a redesign of the terminal.

84 With a transporting machine stationed on the pier itself, doing the hoisting and lowering of loads, the variation of level due to tides could be ignored since the cost of hoisting goods a few additional feet has no material effect on costs or time. Upper stories could then be utilized to advantage. As a rule a second floor is used only for warehouse purposes with the result that all is confusion on the pier floor, due to wagons both receiving and delivering goods. In many cases the pier floor is divided longitudinally into two portions by a pit down the center in which are placed cars for loading or unloading. Communication between these two platforms is maintained through the cars, and, if there is more than one line of them, by "spotting" them or by movable bridges.

85 It is suggested in the first place that no teams be allowed on the pier floor. The loads could be received or delivered at the end of the pier by the transporting machine and the space required for the teams could be utilized for other purposes. It is also suggested that each pier shed be of two floors at least, the upper floor being better adapted for incoming merchandise, since the customs officials will then have the goods on a floor apart from everything. It is evidently as easy to transfer goods to this floor from the ship or to deliver them again to teams or cars as from the first floor. Cars to be loaded can be placed on tracks on the pier between the shed and the pier edge. The lower floor could then be reserved for outgoing freight, and tracks provided for cars to be unloaded. If desired these cars could be easily loaded through hatches in the floor of the second story. As the transporting machinery would operate on overhead tracks the cars inside or outside the shed would offer no obstruction.

86 It is claimed that the cause of the decline in water transportation is due to the limited facilities for receiving and delivering the goods as well as the costly delays at the terminals. If the installation of machinery and the redesign of terminals can obviate these objections will not both shipper and carrier be the gainers?

87 In concluding the writer realizes that the subject has been treated in a general manner only. The problem is a broad one and consists not merely in the installation of certain machinery, but in the study of the changes such an innovation will make in the entire operation of the transportation system as well as the effects on costs, rates and revenue. It is not simply the adaptation of an overhead, electrically-operated carrier system to the present arrangement of terminals, but rather a redesign of the terminals and a radical change in methods of carrying on the terminal business.

88 In solving this problem let there first be a realization of what changes mechanical freight handling might make possible and then abandoning all old ideas and practices to take up the subject as an entirely new problem and work out the solution unhampered by tradition and prejudice. The subject deserves careful study and investigation. Every transportation company could afford, considering the economies that will be effected, to establish a separate department to work out this problem or to employ outside expert services for the purpose. The scope of such investigation and application is not limited to the mechanical and electrical features involved, but requires the services of men also familiar with all phases of the practical transportation problem.

STRESSES IN TUBES

By Prof. Reid T. Stewart

ABSTRACT OF PAPER

This investigation shows that the stresses in the wall of a tube exposed to external fluid pressure are of the same character as those in a column having ends fixed in direction.

Using the experimental results obtained by the author for the collapsing pressures of commercial steel tubing, 3 to 12 in. in diameter, he has derived equivalent column formulae upon the assumption that the circumferential stress in a tubular annulus subjected to external fluid pressure is theoretically the same as in a straight column, with fixed ends, whose length is one-half the mean circumference of the tubular annulus.

These formulae are

$$S = 42{,}640 - 127.4 \frac{l}{r} \quad \text{(K)}$$

$$S = 708{,}000{,}000 \left(\frac{r}{l}\right)^3 \quad \text{(L)}$$

formula (K) being for values of $\frac{l}{r}$ less than 230, while (L) is for values greater than this; where S represents the axial load on column, in lb. per sq. in., and the length of the column divided by least radius of gyration, both in the same unit.

STRESSES IN TUBES

AN INVESTIGATION SHOWING THAT THE STRESSES IN THE WALL OF A TUBE EXPOSED TO AN EXTERNAL FLUID PRESSURE ARE OF THE SAME CHARACTER AS THOSE IN A COLUMN HAVING FIXED ENDS

By Prof. Reid T. Stewart, Pittsburg, Pa.

Member of the Society

While engaged in planning a series of collapsing tests on commercial lap-welded steel tubing, the principal results of which are recorded in the Transactions of the Society,[1] the writer made a theoretical investigation of the stresses in the wall of a tube exposed to external fluid pressure. It was thought that the results of this theoretical investigation would aid in conducting the experiments on a more scientific basis and also serve to simplify the working up of results. The writer was led to believe that an annulus near the middle of a long tube exposed to external fluid pressure is subjected to the same kind of stress that exists in a column whose ends are fixed in direction when loaded axially. The following is a brief synopsis of this investigation, together with a comparison of the results obtained by the use of these new column formulae with the results of actual tests of columns and struts having ends fixed in direction.

2 *Apparent Theoretical Stresses in the Wall of a Tube Exposed to External Fluid Pressure.* Fig. 1 represents an annulus, 1 in. long, located near the middle of a long tube that is perfectly circular in cross section. Let p represent the external fluid pressure in lb. per sq. in. and T the resulting tangential stress in the wall due to this fluid pressure. Now if δa represents, in angular measure, an increment of the circumference of this annulus, then an increment of the area exposed to the external fluid pressure will be $\frac{1}{2}\, d\, \delta a$. The

[1] Vol. 27, pp. 730-822.

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normal pressure on this increment of area will be $\frac{1}{2} p\, d\, \delta a$, and the component of this pressure parallel to the line of action of the tangential stress T will be $\frac{1}{2}\ p\ d\ \sin a\ \delta a$. Therefore the tangential stress

$$T = \tfrac{1}{2}\int_0^{\pi} \tfrac{1}{2}\ p\ d\ \sin a\ \delta a = \tfrac{1}{2}\ pd \ldots\ldots\ldots\ldots [1]$$

Since the tube is assumed to be perfectly circular in cross section and of uniform thickness, this formula shows: (*a*) that the circumferential stress in all parts of any annulus of a tube exposed to an external fluid pressure is constant; and (*b*) that this constant circumferential stress per in. length of tube equals the fluid pressure in lb. per sq. in. multiplied by one-half the outside diameter in ins.

3 *Apparent Stresses in a Tube Annulus Compared with those in a Column or Strut.* Fig. 2 shows one-half of a tube annulus with the

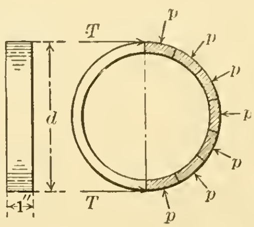

FIG. 1 ANNULUS OF UNIT LENGTH AT THE MIDDLE OF A LONG CIRCULAR TUBE

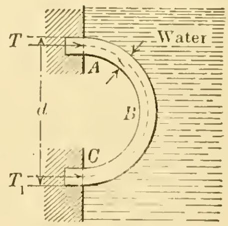

FIG. 2 HALF ANNULUS WITH FIXED ENDS

ends fixed in direction, the outside surface of the half annulus being exposed to a fluid pressure. Evidently the laws above deduced for the complete annulus apply without modification to the half annulus when its ends are fixed in direction, at the same time being free either to recede or to approach each other. All portions of this half annulus, then, are subjected to the compressive stress T (Formula 1) which acts circumferentially in the direction ABC. Opposing this, of course, is the equal circumferential stress T_1, acting in the direction CBA. By straightening the half annulus (Fig. 2) so as to bring A, B and C into the same straight line, the column or strut shown in Fig. 3 will result. It is evident that the forces T and T_1 are each rotated by this action through 90 deg. This shows that the theoretical stresses in a tubular half annulus are identical with those of the column having ends fixed in direction, when the length of the column equals the

mean semicircumference of the annulus, the two, of course, having the same cross section.

4 It will become evident from a comparison of Figs. 4 and 5 that we should take for the length of a column having fixed ends, the half circumference of an annulus located near the middle of a long tube exposed to an external fluid pressure. Fig. 4 shows the ideal collapse section for all the long tubes tested. It will be observed that the tangents to the annulus at both the highest and lowest points before collapse, as shown by the dotted lines, are precisely parallel to the tangents at the same points after collapse. In other words, these portions of the annulus while undergoing deformation remain fixed in direction. Comparing this with Fig. 5, which shows the most

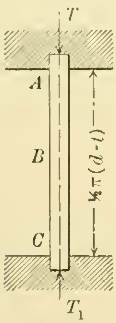

FIG. 3

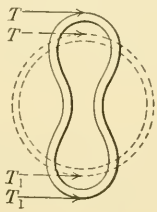

FIG. 4

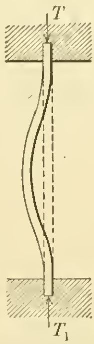

FIG. 5

FIG. 3 STRUT REPRESENTING HALF ANNULUS STRAIGHTENED
FIG. 4 IDEAL COLLAPSE SECTION FOR LONG TUBES
FIG. 5 MOST PROBABLE MANNER OF COLUMN FAILURE

probable manner of buckling of a long column having fixed ends, it will be seen that the two are identical as regards apparent stresses for the conditions above stated, namely, when the annulus is perfectly circular and of uniform cross section, the length of the column with fixed ends being equal to the mean half circumference of the annulus.

5 As the tube annulus departs from the circular form, while failing under fluid collapsing pressure, new stresses arise which have no counterpart in the equivalent column. An investigation has shown that these stresses are slight for small departures from roundness, so that for commercial tubing exposed to external fluid pressure the stresses are substantially the same as those in an equivalent column as illustrated above.

6 *The Author's Formula [B] for the Collapsing Pressures of Steel Tubes Reduced to an Equivalent Column Formula.* In order that he might be able to test the accuracy of the above theoretical deductions, the author has transformed his formula [B] for the collapsing pressures of lap-welded bessemer steel tubes[2] so that it may be used for calculating the crippling strength of columns or struts with fixed ends. This transformation was effected as follows:

7 Referring to Figs. 2 and 3, which represent respectively a half annulus of the tube and its equivalent column or strut, it is evident that the length of the equivalent column will be

$$l = \frac{\pi}{2}(d-t) \text{ or, } \frac{d}{t} = \frac{2l}{\pi t} + 1 \qquad [2]$$

where d and t represent respectively the outside diameter and the thickness of the wall of the tube in in. and π the ratio of the circumference to the diameter of a circle. Since $t = 3.464\ r$, where r equals the radius of gyration of cross section of the annulus and of its equivalent columns,

$$\frac{d}{t} = \frac{2l}{3.464\ \pi r} + 1 = 0.1838\frac{l}{r} + 1 \qquad [3]$$

$$p = \frac{2T}{d} = \frac{2tS}{d} \qquad [4]$$

where p represents the external fluid pressure in lb. per sq. in., T the total circumferential stress in the wall of the annulus 1 in. long, and S the total circumferential stress per sq. in. of cross section, both being expressed in lb. Also, t and d, as before, represent respectively the thickness of the wall and the outside diameter of the tube, in in. Formula [B], using the same notation as before, is

$$p = 86{,}670\frac{t}{d} - 1386 \qquad [B]$$

By equating the second members of equations [4] and [B] we get

$$\frac{2tS}{d} = 86{,}670\frac{t}{d} - 1386$$

from which

$$S = 43{,}335 - 693\frac{d}{t} \qquad [5]$$

[2] Trans.Am.Soc.M.E., vol. 27, p. 793.

By substituting the value of $\frac{d}{t}$ from equation [3] we get

$$S = 42{,}640 - 127.4\frac{l}{r} \qquad [K]$$

8 This is a formula for the crippling strength of a column with fixed ends, as derived directly from formula [B] for the collapsing pressures of long tubes that are exposed to external fluid pressures. In this formula, S represents the axial load on the column in lb. per sq. in. of cross section, while $\frac{l}{r}$ represents the slenderness ratio, or the length of column divided by the least radius of gyration of cross section, both being expressed in the same lineal unit.

9 Since formula [B] is applicable to values of thickness divided by outside diameter $\left(\frac{t}{d}\right)$ greater than 0.023, formula [K] should be applicable to values of length of columns divided by least radius of gyration, $\frac{l}{r}$, less than

$$\frac{\frac{\pi}{2}(d-t)}{\frac{t}{3.464}} = 1.732\,\pi\left(\frac{d}{t} - 1\right) = 1.732\,\pi\left(\frac{1}{0.023} - 1\right) = 230$$

Note that formula [G][3] is tangent to formula [B] at $\frac{t}{d} = 0.024$, which gives a slenderness ratio $\left(\frac{l}{r}\right)$ at point of tangency of 221, which latter should therefore be the true limiting value of r for formula [K] when used in connection with formula [L] as given below.

10 *The Author's Formula* [G] *for the Collapsing Pressures of Steel Tubes Reduced to an Equivalent Column Formula.* In a manner similar to the above derivation of formula [K] the author's formula [G] has been transformed into an equivalent formula for the crippling strength of long columns or struts. Using the same notation as before collapse formula [G] which is applicable[3] to values of $\frac{t}{d}$ less than 0.024, is

$$p = 50{,}210{,}000\left(\frac{t}{d}\right)^3 \qquad [G]$$

[3] Trans. Am.Soc.M.E., vol. 27, p. 795.

and its equivalent column formula, derived in a similar manner, is

$$S = 25{,}105{,}000 \left(\frac{1}{0.1838 \frac{l}{r} + 1} \right)^2 \ldots\ldots\ldots\ldots [6]$$

which is applicable to values of $\frac{l}{r}$ greater than 221, as stated above. This somewhat complex formula is represented with sufficient accuracy for all practical purposes by the following simple formula:

$$S = \frac{708{,}000{,}000}{\left(\frac{l}{r}\right)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [L]$$

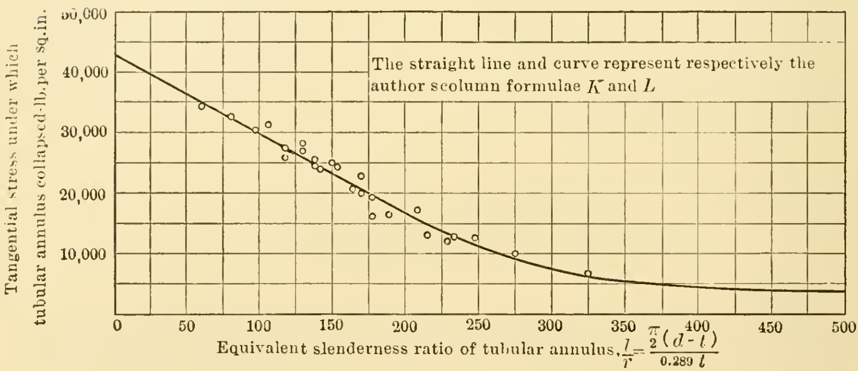

FIG. 6 PLOTTED RESULTS OF THE AUTHOR'S EXPERIMENTS ON COLLAPSING PRESSURES OF LAP-WELDED STEEL TUBES

where S as before, represents the axial load on the column in lb. per sq. in. of cross section, and $\frac{l}{r}$ the length divided by least radius of gyration of the column, both being expressed in the same lineal unit. This formula applies only to columns having both ends fixed in direction and for values of $\frac{l}{r}$ greater than 221.

11 *Verification of the Author's Column Formulae* [*K*] *and* [*L*] *by Comparison with Results of Tests on Columns.* In order to show that the new column formulae given in this paper are applicable to commercial shapes and annular sections when used as columns with ends fixed in direction, Figs. 6 and 7 were prepared. The only tests on

commercial struts and columns with fixed ends known to the writer are those made by James Christie on wrought-iron struts,[4] and those made at the Watertown Arsenal[5] in 1909.

12 The average physical properties of the iron in the struts tested by Mr. Christie were

Tensile strength, lb. per sq. in.	49,000
Elastic limit, lb. per sq. in.	32,000
Elongation in 8 in., per cent.	18

while those of the steel constituting the lap-welded tubes tested by the writer and at the Watertown Arsenal were

Tensile strength, lb. per sq. in.	58,000
Yield point, lb. per sq. in.	37,000
Elongation in 8 in., per cent	22

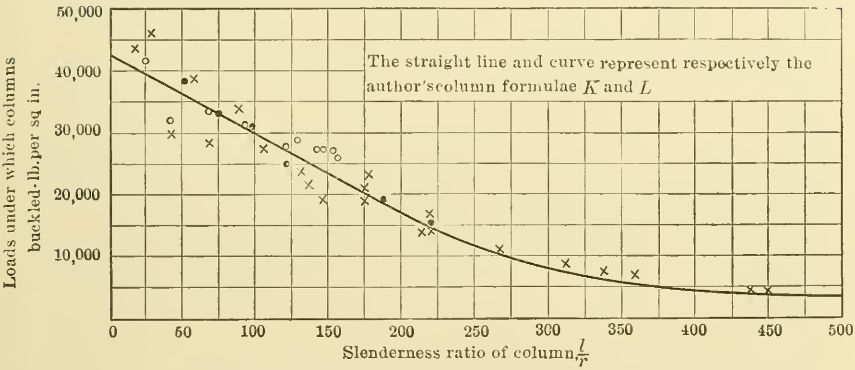

FIG. 7 PLOTTED RESULTS OF VARIOUS COLUMN EXPERIMENTS

(x) indicates plotted results of Christie's experiments on wrought-iron angles ranging from 4 in. × 4 in. × $\frac{3}{8}$ in. to 1 in. × 1 in. × $\frac{1}{8}$ in., with fixed ends.

(•) indicates plotted results of Christie's experiments on lap-welded wrought-iron tubes used as columns with fixed (flanged) ends.

(o) indicates plotted results of Watertown Arsenal experiments on lap-welded steel tubes, 5 in. outside diameter, used as columns with fixed ends.

13 These data show that the material of the angles and tubes tested by Mr. Christie as compared with those of the tubes tested by the writer and at the Watertown Arsenal had average physical properties less by 15 per cent in tensile strength, 13 per cent in elastic limit, and probably less that 10 per cent in modulus of elasticity, or rigidity factor. It should be remembered while comparing the results

[4] Trans. Am.Soc.C.E., 1884, p. 117.

[5] Proceedings, American Society for Testing Materials, 1909, p. 413.

of these experiments, that these differences in the physical properties of the materials, which it will be noticed are comparatively small, will be more or less offset for two reasons: (*a*) the tubular annulus at the point of failure varies somewhat more from being truly circular than does the strut from being truly straight; and (*b*) there is a small bending moment on the wall of the tubular annulus directly due to the action of the external fluid pressure on an annulus that is slightly out of round, for which there is no counterpart in the equivalent column.

14 Fig. 6 represents the plotted values of the results of the writer's experiments on the collapsing pressures of lap-welded steel tubes. These results are plotted to a horizontal scale representing the equivalent slenderness ratio of the semi-tubular annulus considered as being under the same conditions of stress as a column with ends fixed in direction (Figs. 2, 3 and 4). Since the mean semicircumference of the tube annulus equals $\frac{\pi}{2}(d-t)$ and the radius of gyration of the section equals $0.289t$, this slenderness ratio will be $\frac{l}{r} = \frac{\frac{\pi}{2}(d-t)}{0.289\,t}$. The vertical scale represents the apparent tangential stress T (Fig. 2), under which the tubular annulus actually failed.

15 Fig. 6 represents the plotted values of the group averages of Series 2 of the author's experiments on the collapsing pressures of lap-welded steel tubes, 3 to $12\frac{3}{4}$ in. outside diameter.[6] The straight portion of the line represents the writer's column formula [*K*] plotted to the same scales, while the curved portion similarly represents column formula [*L*].

16 Fig. 7 represents the plotted values of all results of tests on commercial struts and columns with ends fixed in direction known to the writer. It should be noted here that practically all tests of commercial columns and struts have been conducted under the condition of flat, pin, or round ends.

[6] Trans., Am.Soc.M.E., vol. 27, pp. 787-802.

THE ASSEMBLY OF SMALL INTERCHANGE-ABLE PARTS

By John Calder

ABSTRACT OF PAPER

The direct labor cost of assembling small interchangeable parts is a comparatively large item in light mechanical engineering and repetition work.

Economical production demands that easy assembly be kept in view at all stages from the design of a mechanism and through the tooling and shop processes to the delivery of the unit parts to the assembler.

The paper analyzes and illustrates all the elements which should enter into the producer's calculations and outlines the works organization necessary to secure the rapid and economical production of suitable unit papers. It describes the results obtained in the assembly of given pieces and illustrates the simple apparatus used and the place that preliminary time and motion study has in assuring the shop shall, from the first, begin operating upon the assembly of the mechanism under the most economical conditions.

THE ASSEMBLY OF SMALL INTERCHANGEABLE PARTS

By John Calder, Ilion, N. Y.

Member of the Society

In the branches of mechanical engineering and manufacturing devoted to complicated and highly finished business and domestic appliances, as distinguished from the many simpler and rougher forms of hardware, the direct labor costs of assembling the numerous small interchangeable parts are very important items. They often considerably exceed the whole cost of the material and the expense incurred upon them is much more within the control of the management.

2 Long before any proposals were made towards the general modification of the day-rate system of labor reward in most plants, the large industries mentioned had been driven by necessity to cheapen and intensify production by methods more or less systematic.

3 The movement in mechanical engineering in recent years towards scientific time study of labor tasks owes much to the proceedings of the Society, particularly to the contributions and well-considered generalizations of Fred. W. Taylor and H. L. Gantt. It is now fully realized that the scientific principles advocated are simply common sense organized to a very high degree and that what is needed is not so much expert advice and staff and equipment changes as a firm realization of the possibilities by an efficient management and the ability successfully to inoculate the existing organization with like optimism.

4 This movement found many interchangeable parts industries in a very favorable position to profit by it and not a few of them have resumed the economical evolution of their processes and labor methods along the new lines at a rapid pace after a period of more or less stagna-

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tion. They have accomplished this in many cases by adopting the new principles in full, but using the existing staffs and appliances and dispensing with the capital outlays and outside expert aid which is sometimes absolutely necessary in machine shops when the change of system is very marked.

5 Table 1 is a typical organization chart for a works employing several thousand people in the interchangeable parts industry when the great bulk of the parts production is assembled into finely adjusted machines. It is the purpose of this paper to outline and illustrate briefly the principles upon which the parts assembly department is conducted, but they are equally applicable to all the manufacturing branches indicated on the chart.

6 Economical parts assembly implies, among other things, the securing for such operations in shop practice at the initial stages in the history of a new part of

a The highest assembly speed and

b The prescribed quality of work; neither more nor less.

7 If these conditions are fulfilled, the best economy will be most quickly attained when

c The classes of labor available are properly selected, graded and trained.

8 Economical assembly is sometimes attained by indirection, after a long drawn-out and intermittent process of elimination, trials and modifications based upon rough occasional observations by foremen and others of ordinary workers in the shop. This course is costly, uncertain and slow, and early expensive and inefficient conditions are apt to be perpetuated.

9 Starting with small interchangeable parts of the most practicable form, the management of such a works is in a position to determine for itself, without the guesswork sometimes neccessary in complicated machine tool operations, the best assembly arrangements of apparatus and of labor. Any plant doing light repetition work in quantities can afford to devote a small inexpensive department entirely to this task and to cease the guessing methods, whether aided by premiums or not, which often do duty for painstaking time study and efficient initial criticism of apparatus and routine.

10 Certain preliminary precautions and results in the machine shop and other departments producing the unit pieces to be assembled are necessary, such as

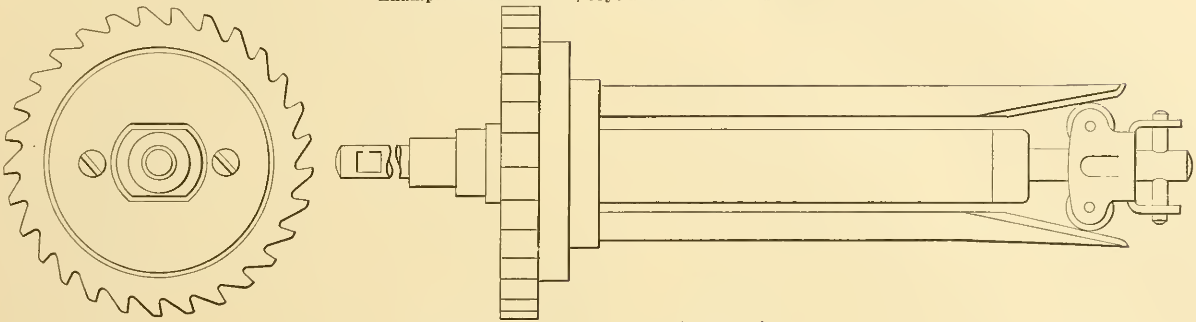
d The designing of the form of the part with quick assembling in view.

TABLE 1 ORGANIZATION OF LARGE WORKS MAKING AND ASSEMBLING SMALL INTERCHANGEABLE PARTS

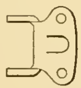
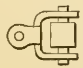
- MANAGER
  - EXECUTIVE DEPARTMENTS
    - GENERAL OFFICE
      - Correspondence
      - Cashier and Bookkeeper
      - Industrial Betterments
        - Works "Bulletin"
        - Suggestion System
        - Foremen's Club House
        - Works Band
        - First Aid
      - Time Records and Payroll
      - Rate Records
      - Costing and Inventories
    - PURCHASING
      - Purchasing Raw Material and Supplies
      - Receiving Clerk, Teams, R R. Siding
      - Raw Material and Supply Stores
    - FINISHED PARTS AND PRODUCTION ORDERS
      - Finished Parts Stock Room
      - Issues all Production Orders for Parts
      - Issues all Parts for Machine Manufacture
    - SHIPPING
      - Stock of Finished Machines, Packing Room
      - Shipping and Billing Machine and Part Orders
    - WORKS ENGINEERING
      - Light, Heat, Power, Ventilation
      - Millwrights, Electricians, Plumbers
      - Fire Corps, Watchmen, Yard Labor
  - MANUFACTURING DEPARTMENTS Superintendent
    - MANUFACTURE OF PARTS Asst. Supt. and Foremen
      - Pattern Shop
      - Brass Foundry
      - Iron Foundry
      - Japanning
      - Tinsmiths
      - Drop Forging
      - Punch and Press Work
      - Automatic and Hand Screw
      - Annealing and Hardening
      - General Grinding
      - Light Milling and Drilling
      - Cast Iron Milling and Drilling
      - Polishing
      - Plating and Buffing
      - Wood and Rubber Working
      - Assembling Compound Parts
      - Tool Designing and Model Making
      - Tool Making
      - Inspecting Parts
      - Testing Rates and Methods
    - MANUFACTURE OF MACHINES Asst. Supt. and Foremen
      - Assembling Machine Group No. 1
      - Assembling Machine Group No. 2
      - Assembling Machine Group No. 3
      - Assembling, Final Stage
      - Inspecting Machines
      - Adding Special Fixtures
      - Rebuilding Machines
      - School of Repairing

TABLE 2 DIVISION OF LABOR AND SPEED OF WORKERS IN ASSEMBLING SMALL INTERCHANGEABLE PARTS

Examples where women, boys and men are used



Assembled Piece Clutch No.31531 (Full Size)

Stage No.	Unit Parts 18 in Number Assembled in 10 Stages	Operations in Sequence	Grade of Labor	Average Time Including Stops, from Records of 100,000 Pieces	
				Min.	Sec.
1		Ream 2 holes 0.073″ in Roll Holder No.30670 on speed lathe	Women	0	7
2		Assemble roll holder No.30670 2 rolls No.30680 and 2 pins No.67640 at bench	Boys	0	45
3		Ream 1 hole 0.166″ in clutch frame No.30361 on speed lathe	Women	0	5

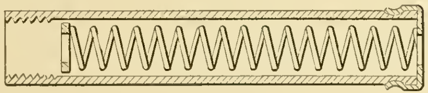
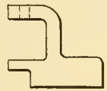
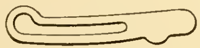
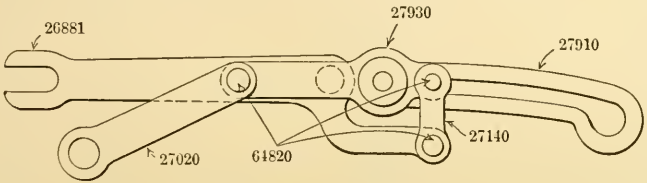
4		Tap 2 holes 0.08″–56 in clutch frame No.30361 on tapping machine	Men	0	16
5		Ream 2 holes 0.085″ and 0.059″ in shaft No.31620 on speed lathe	Women	0	10
6		Straighten shaft No.31620 on bench block	Boys	0	8
7		Put pin No.65610 in shaft No.31620 with bench fixture	Boys	0	20
8		Put in washer No.90000 and assemble tube No.31521 and spring No.67210 at bench	Men	2	24
9		Bend and gage clutch jaws No.30690 in bench visc	Men	0	31
10	See full-size sketch	Assemble clutch jaw No.30690 ratchet No.30370, frame cover No.30330, 2 screws No.70402, and roll holder comp., with pins No.64650 at bench	Men	3	52
	The direct labor cost of assembling 1 clutch No.31531 is 3.784 cents	Average time to assemble 18 unit parts to form clutch No.31531	Women Boys and Men	8	40

TABLE 3 DIVISION OF LABOR AND SPEED OF WORKERS IN ASSEMBLING SMALL INTERCHANGEABLE PARTS

Examples where men only are used

Unit Parts 15 in Number Assembled in 9 Stages	Stage No.	Operations in Sequence	Grade of Labor	Average Time Including Stops, from Records of 100,000 Pieces	
				Min.	Sec.
	1	Ream 1 hole to size 0.101″ in support bracket for ribbon driving arm No.27060 on speed lathe	Men	0	10
	2	Ream 1 hole to size 0.101″ in ribbon position adjusting arm No.27910 on speed lathe	Men	0	10
	3	Ream 1 hole to size 0.101″ in ribbon shifting arm No.27930 on speed lathe	Men	0	10
	4	Burnish adjusting arm No.27910 on bench	Men	0	12
	5	Assemble driving arm, No.26881 shifting link No.27020, connecting link No.27140, stud for adjusting arm No.27150, adjusting arm No.27910 shifting arm No.27930 and 3 rivets No.04820 on bench	Men	0	48

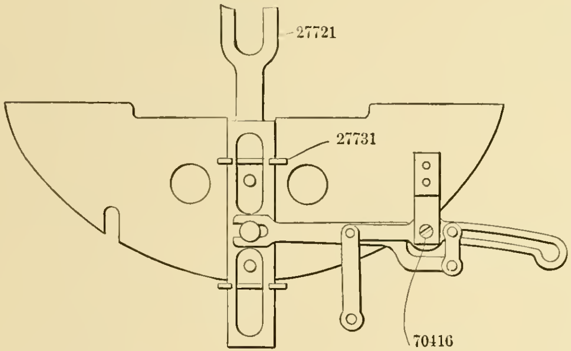
	6	Bend and gage carrier No.27721 to bench fixture	Men	1	12
 	7	Assemble support bracket No.27060 and guide No.27731 with 2 screws No.74410 on bench	Men	1	2
	8	Fit carrier No.27721 and guide No.27731 on bench	Men	1	36
	9	Final assembling of riveted links with carrier No,27721 and guide No.27731 with screw No.70416, on bench	Men	1	58
Assembled Piece No.27710 (Half Size)	The direct labor cost of assembling No.27710 is 4.195 cents	Average time to assemble 15 unit parts into 1 carrier guide and driving arm No.27710	Men	8	18

TABLE 4 DIVISION OF LABOR AND SPEED OF WORKERS IN ASSEMBLING SMALL INTERCHANGEABLE PARTS

Examples where women only are used

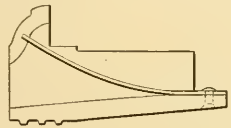
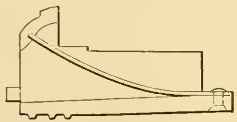
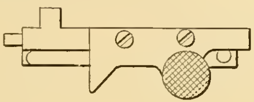
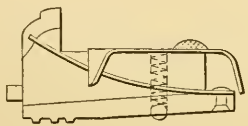
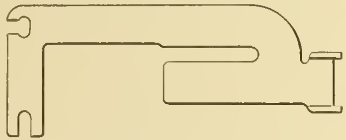
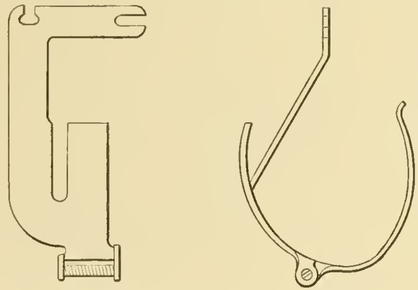
Unit Parts Ten in Number Assembled in Three Stages (Full Size)	Stage No.	Operations in Sequence	Grade of Labor	Average Time Including Stops from Records of 100,000 pieces	
				Min.	Sec.
	1	Assemble stop No.36202 and spring No.66220 with rivets No.64950 on Bradley hammer.	Women	0	45
	2	Drive pin No.64750 in stop No.37612 on bench.	Women	0	12
	3	Assemble locating ball No.16100, spring No.67150, indicator No.36180 with screws No.70000 on bench.	Women	0	36
	The direct labor cost of assembling one margin stop No.37612 is 4 mills	Average time to assemble 10 unit parts to form one margin stop No.37612	Women	2	33

TABLE 5 DIVISION OF LABOR AND SPEED OF WORKERS IN ASSEMBLING SMALL INTERCHANGEABLE PARTS

Examples where boys only are used

Unit Parts Four in Number Assembled in Two Stages	Stage No.	Operations in Sequence	Grade of Labor	Average Time Including Stops from Records of 100,000 pieces Min.	Sec.
	1	Tap one hole 0.100″–48 in support No.26571 on tapping machine.	Boys	0	6
	2	Assemble support No.26571, tension finger No.26580, spring No.67400 with screw No.70838 and gage by weight test on bench.	Boys	1	15
(Half Size)	The direct labor cost of assembling one No.27520 is 6½ mills.	Average time to assemble 4 unit parts to form one spool guard No.27520.	Boys	1	21

e The designing and proper maintenance of efficient tools, jigs and fixtures, working to practicable limits in the dimensions and fits.

f An efficient parts inspection service, securing in every department adherence to these limits and the rejection of all defective unit parts.

g The adoption for each unit piece of a shop routing in machine and other departments which will produce the fitting surfaces in the conditions permitting the least work in assembling. The total abolition of the file or other cutting tools at the bench should be aimed at.

11 If the foregoing conditions are observed, the speed of assembly will then depend upon

h The extent to which the division of labor is carried.

i The thoroughness of the time study of skilled demonstrators in each division, including the elimination of lost motion and the criticism of the machined unit pieces.

j The efficiency of the mechanical facilities provided by the management for aiding the work of assembly.

12 If the above ten conditions (*a* to *j* inclusive) are by suitable organization fulfilled for any new piece before it is presented to the workers in any way and the assembly work done is accepted only after passing an efficient inspection, a straight piecework system of remuneration will often be found best in the interests of employer and employee alike.

13 After such a close preliminary study and exhaustive development of the possibilities, there is no such margin remaining as obtains in the rough approximations of premium setting where the processes are often left to evolve slowly and uncertainly at the initiative of the workers and overseers alone. The employees, therefore, may well be given the whole of their gains on the prescribed standard task.

14 Tables 2 to 5 show a few examples of the division of labor and speed of workers on straight piece-work tasks in the assembly of small interchangeable parts, where all the conditions essential to the highest economy have been thoroughly and expeditiously worked out before the assembly task is presented to the manufacturing department. Table 2 gives the final arrangements as determined by the task and method department for a mechanical assembly using the labor of men, women and boys, while Tables 3, 4 and 5 are examples of three mechanical tasks performed by men, women and boys separately.

15 Owing to the minute division of labor and the elimination by careful study of all lost motion, most of the tabulated assembly stages, it will be noted, are performed in much less time than it takes to describe them. About three-quarters of a million unit pieces of several thousand varieties are handled daily on the principles laid down, passing successively through most of the 27 manufacturing departments indicated in Table 1. The total operations involve the use of about 20,000 straight piece rates, each based upon the results of exact preliminary time and method studies.

16 *Apparatus.* The course followed in attaining such results varies according to the nature of each department, but the main features are the same for all and will be sufficiently indicated, the

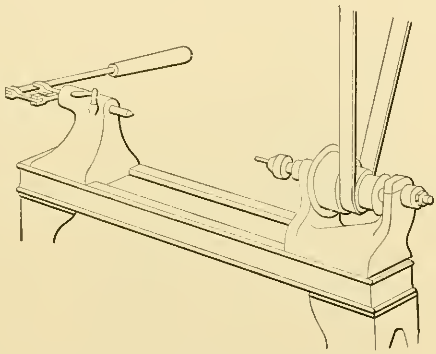


Fig. 1 Power Speed Lathe

writer believes, by describing the concrete parts assembly tasks of Tables 2 to 5. In addition to an ordinary bench vise, a 4-oz. hammer, a bench anvil block and screw-drivers, the rest of the tools used consist of simple machines and fixtures, and embrace the following: a power speed lathe (Fig. 1), a vertical power tapping machine (Fig. 2), a bench pin-insertion fixture (Fig. 3), a Bradley hammer (Fig. 4), a horizontal power tapping machine (Fig. 5), a bench gage fixture (Fig. 6).

17 It will be noted that the file is absent from the above list. The possession or use by any assembler of this mechanical persuader toward a fit is forbidden, unless after due cause shown and under special permit. The writer has found that such a prohibition will often throw a considerable amount of new light upon the real condi-

tion and suitability of the machined surfaces prepared in the other shops and which have passed the prescribed gage tests. The general tendency of this course is to raise the whole level of machine shop practice and to help greatly in locating more definitely for the tool designer and maker needed refinements and corrections in the jigs and fixtures, as well as in other processes.

18 *Method.* Prior to the introduction into the shops of any new assembly operations, such as those described, the prescribed apparatus, which is the best that the collective experience of superintendent, foreman and tool engineer can devise, is handed over to the time and motion study department, whose few expert employees proceed to operate with it on a manufacturing scale. They handle large quanti-

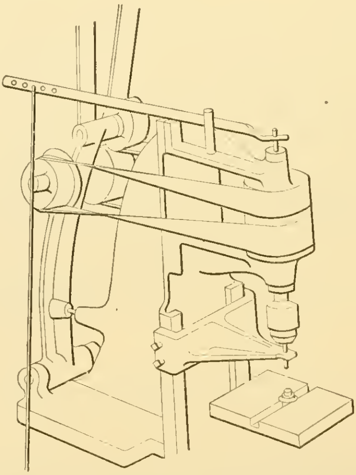


Fig. 2 Vertical Power Tapping Machine

ties of product which is subject to all the usual inspection tests and passes into the manufacture. In this way the cost of the time study department is reduced to a very small figure, for the working time of its experts is fully as productive as that of the shop. These few experts have been selected and organized from the ranks of ordinary employees in the works who have shown considerable versatility and the power of comparative observation. When such initial criticism of the apparatus and parts supplied as has been well taken has been put into effect, it is the duty of this department to ask and answer, quickly by expert demonstrations the following questions regarding the particu-

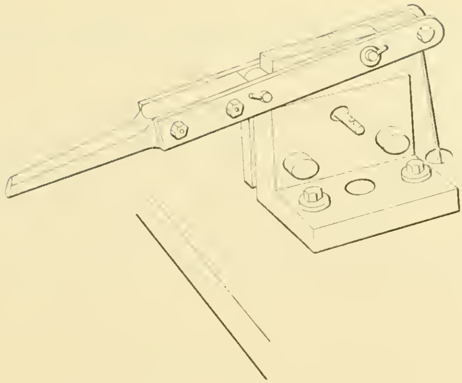


Fig. 3 Bench Pin-Insertion Fixture

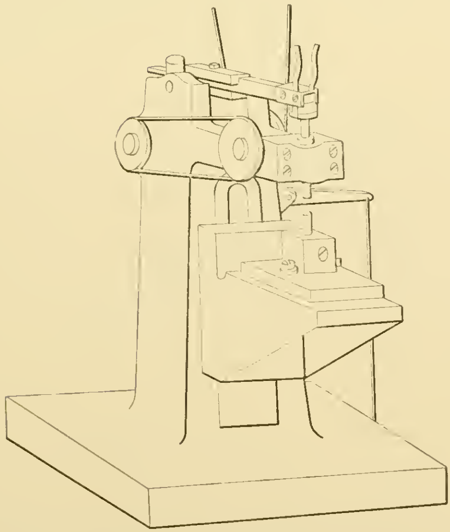


Fig. 4 Bradley Hammer

lar operations cited, the motions being carefully studied as to their necessity and timed as to their duration:

a Best height and position of the seat or chair for the operator (male or female) at the bench or machine.

b Best position in front, or on right or left of operator, of the several stocks of each unit piece comprised in the assembly task.

c Best position of the hand tools and appliances which the operator has to pick up and apply and lay down again.

d The advantage, if any, which an ambidextrous operator has at any stage and the cultivation of that faculty.

e Best arrangement for bringing forward and removing the work without interrupting the assembly process.

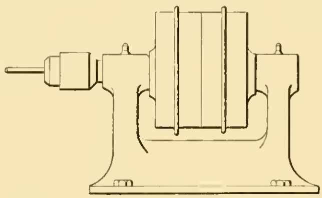


FIG. 5 HORIZONTAL POWER TAPPING MACHINE

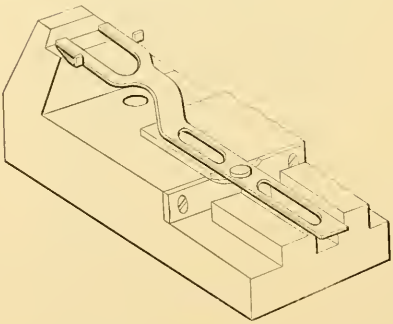


FIG. 6 BENCH GAGE FIXTURE

f Progressive time study under the best conditions of each of the movements finally decided upon as necessary and the combination of all of them on the principle of "least work."

When the possibilities are fully in view a straight piece-rate is fixed, based on these, which will give an industrious worker of average ability in each grade the normal earnings, while the exceptional operator receives the full amount of his surplus.

19 The system described in this paper, for a few tasks of one department only, is applied to all the manufacturing divisions, with details appropriate to their needs. It is also applicable in kind, if not in degree, to economising many functions in the executive division. There is but one study staff of six members for the whole works. These soon record standardized conditions for every class of manual and machine operation and their work on any new problem or revision is quickly and economically performed.

20 The writer does not favor the restriction of the ordinary shop foremen solely to productive supervision but prefers to encourage them to compete freely with the time study staff for the best result. If pains are taken to give publicity to all good suggestions adopted from foremen a surprising amount of very profitable coöperation can be obtained from them, which enhances instead of diminishing their administrative ability.

21 The system outlined here in only one class of application is profitable to employer and employee alike. It is a true conservation and indeed an intensification of capital and labor, two natural resources which need never be exhausted.

PRESSURE-RECORDING INDICATOR FOR PUNCHING MACHINERY

By Prof. Gardner C. Anthony

ABSTRACT OF PAPER

The use of an indicator for the direct recording of stresses due to punching boiler plates, under the working conditions of a boiler shop punch, is believed to be new. This paper is largely descriptive of a device for obtaining cards from an ordnance indicator applied to a pressure cylinder, which enables the operator to obtain results as easily and rapidly as is done in indicating an engine. The cards illustrated were taken under the above conditions and also with the apparatus applied to an Olsen testing machine. The latter was for the purpose of checking certain results and introducing a variety of conditions which it is proposed to investigate.

Although the number of tests so far made is insufficient for conclusive evidence, they have demonstrated the efficiency of the device as a piece of laboratory apparatus which will serve admirably for determining data relating to the following: the maximum pressures for which punching machines should be designed, the point of maximum stress in the punching of plates and other material, the effect on the maximum stress by increasing the clearance between punch and die, the advantages to be derived from the use of shearing punches, and finally, the effect of time on the flow of metal in punching.

PRESSURE-RECORDING INDICATOR FOR PUNCHING MACHINERY

By Prof. Gardner C. Anthony, Tufts College, Mass.

Member of the Society

The design of this device was assigned as the subject for a mechanical engineering thesis at Tufts College, in the endeavor to determine such values as the maximum pressures for which punching machines should be designed, the point of maximum stress in the punching of plates, the advantages to be derived from the use of shearing punches, the effect of increased clearance between punch and die on the maximum stress and the effect of time on the flow of metal in punching.

2 The apparatus was designed to enable indicator diagrams to be taken under the conditions of actual shop practice by applying the mechanism to punching machinery now in use. It was first used in May 1909, at the New England Iron Works, South Boston, where it was applied to a Bisbee-Endicott lever-type punch, for which it was designed. Tests were made on plates of $\frac{1}{4}$ in., $\frac{7}{16}$ in. and $\frac{1}{2}$ in. thickness, with punches of $\frac{1}{2}$ in., $\frac{5}{8}$ in. and $\frac{3}{4}$ in. diameter.

3 Only such tests were made at that time as were deemed necessary to demonstrate the efficiency of the apparatus, since before applying it to a series of tests it was thought desirable to compare the indicator diagrams already taken with those which might be obtained from its application to a testing machine, as illustrated in Fig. 1. This was done in June 1910, when it was applied to a 60,000-lb. Olsen testing machine. The results demonstrated the desirability of continuing the experiments on this machine, since there was but a slight variation in the cards, due to the increased time of punching, while a much greater range of speeds was possible.

4 The number of tests now made are insufficient for conclusive

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evidence concerning the problems relating to shearing stresses, but it was thought desirable to present this application of an indicator as a useful addition to recording devices for testing machines, and to give some results of tests already made for the purpose of stimulating experimental work in this direction.

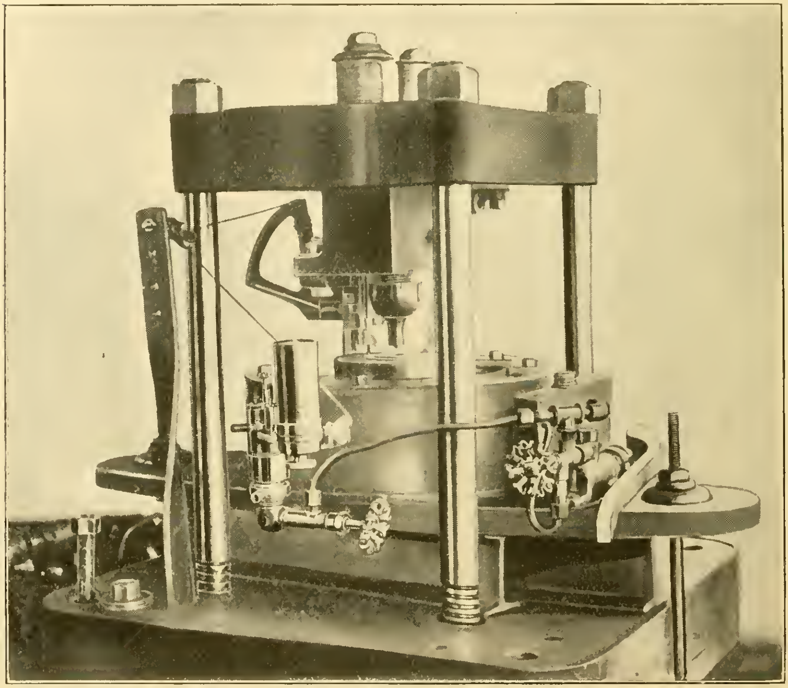


FIG. 1 PRESSURE-RECORDING APPARATUS APPLIED TO TESTING MACHINE

5 The principle employed in the design of the pressure-recording mechanism was that of the Emery testing machine, save that the hydraulic chamber communicates directly with an ordnance indicator, as in Fig. 3, which shows a cross-section of the compression cylinder with the indicator attached and the motion mechanism bolted to the crosshead of a punching machine. The die N is clamped to a piston P, which rests on a thin diaphragm D enclosing a small volume of oil, the pressure of which is recorded by the indicator. The piston has an area of 50 sq. in. and is guided by two annular steel discs fixed between

rings E and F and K and L. These serve to centralize the piston and to eliminate all frictional losses due to surface contact. The die N is held in place by an interrupted screw S, by means of which the die can be removed quickly and the burs, or punchings, removed from the space below. The diaphragm is made of sheet brass 0.007 in. thick and fitted to the grooved space G, at which place the pressure chamber is made tight by a lead packing ring. An air valve and an indicator pipe communicate with this space. The recess on the lower face of the piston serves to make the diaphragm taut by being forced into place when first under pressure, and also permanently to center the piston. The piston and die have a possible motion of 0.025 in., the limits being determined by the lower ring F and the inner flange at the bottom of the cylinder. Only a small part of this motion is

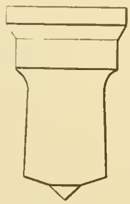


Fig. 2 Type of Shearing Punch Used

necessary, since the ratio of pressure piston to indicator piston is 2000 to 1.

6 Fig. 4 illustrates an oil tank, pump, gage and pipe connections to enable the operator to insure a supply of oil under slight pressure before each operation and to provide for a slight loss through leakage by the indicator piston. The general arrangement of these fixtures is more clearly shown in Fig. 1, which illustrates the mechanism applied to the Olsen testing machine.

7 The motion mechanism for indicating the travel of the punch in the plate is attached to the crosshead of the testing machine or punching machine. It consists of an arc T and a wheel R (Fig. 4), operated by a metallic band connection between the latter and the finger V, which is set in motion by contact with the plate to be punched. The indicator motion ratio is 5.5 to 1.

8 Special punches and dies were made for these tests, both flat and shearing punches being used. The latter were of the type illustrated by Fig. 2. No lubricant was used in these tests.

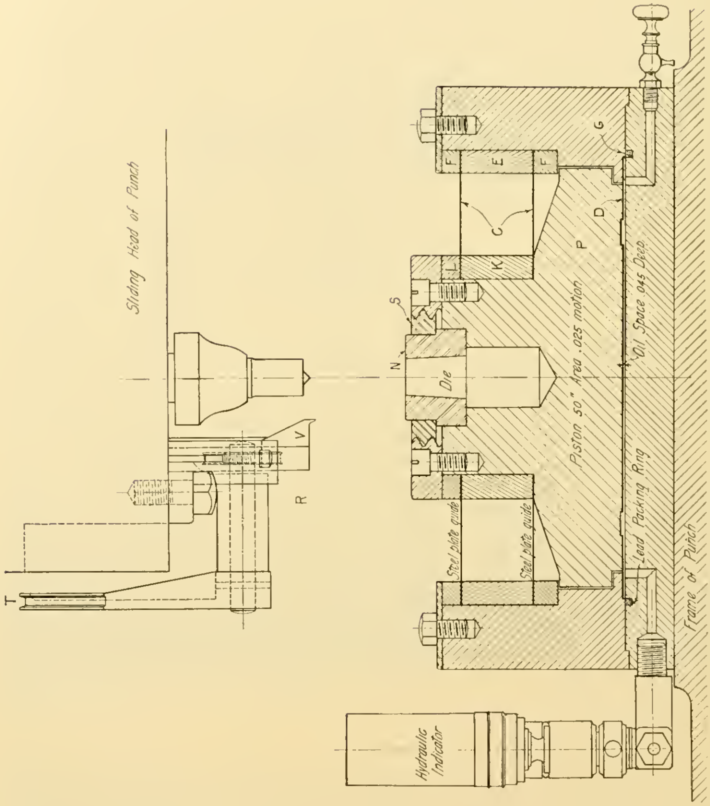


FIG. 3 SECTION THROUGH COMPRESSION CYLINDER

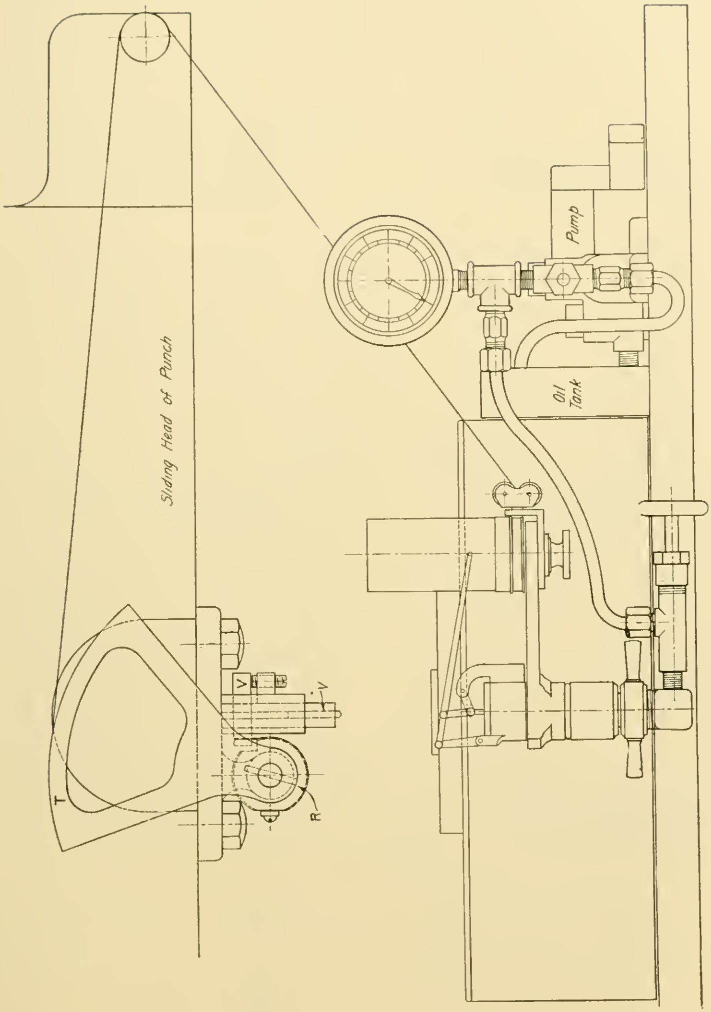
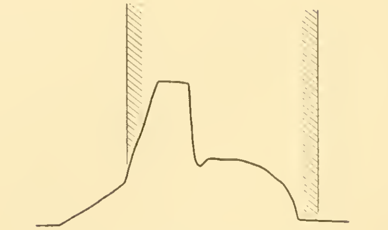
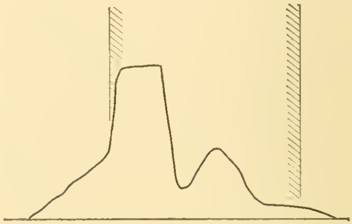


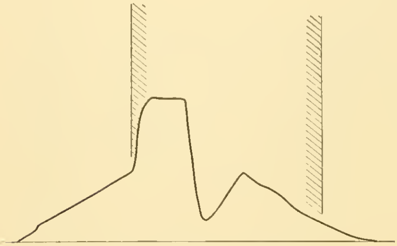
FIG. 4 DIAGRAM OF RECORDING APPARATUS



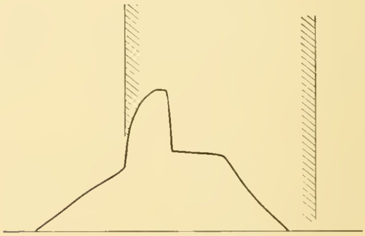
No.1 Die 0.529 Plate 0.257
Punch *F* 400-lb. Spring



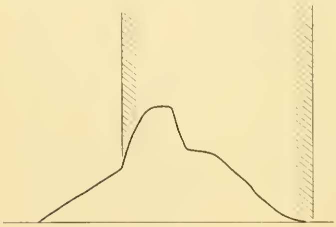
No.3 Die 0.529 Plate 0.257
Punch *F* 400-lb. Spring



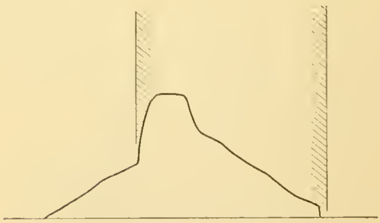
No.9 Die 0.654 Plate 0.257
Punch *F* 500-lb. Spring



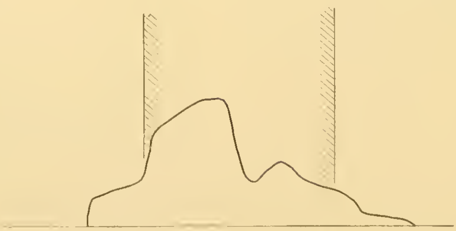
No.38 Die 0.654 Plate 0.257
Punch *F* 500-lb. Spring



No.39 Die 0.654 Plate 0.257
Punch *F* 500-lb. Spring

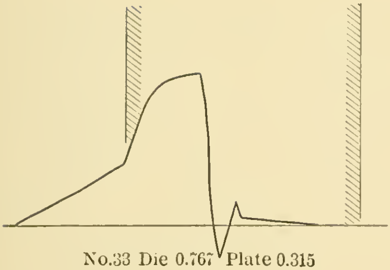


No.40 Die 0.654 Plate 0.257
Punch *F* 500-lb. Spring

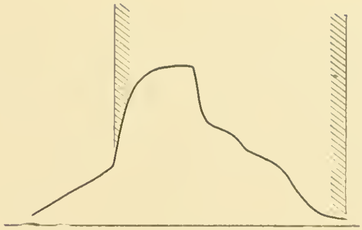


No.7 Die 0.654 Plate 0.257
Punch *S* 500-lb. Spring

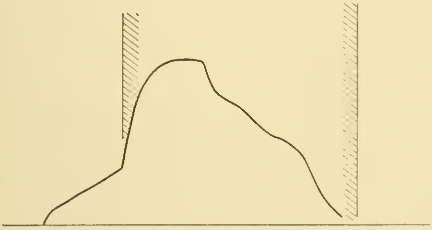
FIG. 5 SPECIMEN DIAGRAMS FROM RECORDER



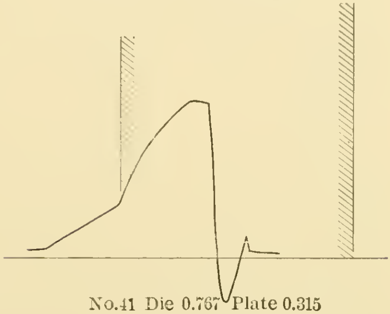
No.33 Die 0.767 Plate 0.315
Punch F 500-lb. Spring



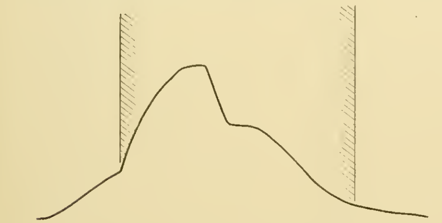
No.34 Die 0.767 Plate 0.315
Punch F 500-lb. Spring



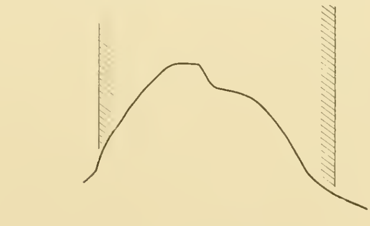
No.36 Die 0.767 Plate 0.315
Punch F 500-lb. Spring



No.41 Die 0.767 Plate 0.315
Punch S 500-lb. Spring



No.42 Die 0.767 Plate 0.315
Punch S 500-lb. Spring



No.43 Die 0.767 Plate 0.315
Punch S 500-lb. Spring

No.19 Die 0.767 Plate 0.500
Punch F 800-lb. Spring

FIG. 6 SPECIMEN DIAGRAMS FROM RECORDER

9 Before taking a card, a datum line of zero pressure was drawn, after which the oil pump was used to obtain a slight pressure in the compression chamber before operating the punch. The series of diagrams shown in Figs. 5 and 6 were reproduced from indicator cards, verticals being drawn in correct relation to the diagrams to indicate the thickness of the plate at the enlarged scale produced by the motion mechanism. Flat punches are designated by F and shearing punches by S. Cards numbered less than 20 were taken on the Bisbee-Endicott punching machine operated under normal conditions. Cards numbered more than 20 were taken on the Olsen testing machine. When punching on the testing machine the stresses were frequently checked by reading the pressures from the scales of the machine.

10 No. 3 is a characteristic card taken while punching a $\frac{1}{4}$-in. mild steel plate with a $\frac{1}{2}$-in. flat punch on the Bisbee-Endicott machine. The inclined line at the left indicates the pressure required to force the point of the punch into the plate, which in this case is about 1000 lb. The maximum stress is obtained at about 6 per cent of the thickness of the plate and is 23,000 lb. This would make the shearing stress about 57,000 lb. per sq. in. The continuance of the pressure to the right of the plate indicates the force necessary to push the bur through the die. Previous to taking card No. 3 the punching machine was operated by hand to test the adjustment of the apparatus and card No. 1 was taken. In this case the pressure under the diaphragm was raised to about 50 lb. before starting to punch, which will account for the abrupt termination of both ends of the card. The maximum stress is the same as that indicated in No. 3, but occurs at about 15 per cent of the thickness of the plate, due to the increase in the time of the operation.

11 The effect on the maximum stress caused by an increase in the time for the passage of the punch through the plate is shown by cards Nos. 9, 38, 39, and 40, in which the range is from about $\frac{1}{4}$ sec. to $8\frac{1}{4}$ min. There is no apparent cause for the rise in the maximum stress of No. 40 and it is possible that the error is in No. 39.

TABLE 1 EFFECT OF TIME ON MAXIMUM STRESS

No.	Time Sec.	Maximum Stress Lb. per sq. in.	Percentage of thickness of plate at which maximum stress occurs
9	$\frac{1}{4}$	31,000	10
38	80	30,000	18
39	310	25,500	18
40	495	26,000	13

12 Card number 7 shows the effect of using a shearing punch under conditions identical with No. 9.

13 The effect on the stress produced by increasing the clearance between the die and punch is shown by the accompanying table and cards Nos. 33 to 43. The tests were made on the Olsen machine, using a die of diameter 0.767 in. and punching a plate 0.315 in. thick.

TABLE 2 EFFECT OF CLEARANCE ON MAXIMUM STRESS

No.	Type of Punch	Dia. of Punch in.	Clearance* in.	Max. Stress Lb. per sq. in.
33	F	0.702	0.065	32,000
34	F	0.738	0.029	33,000
36	F	0.750	0.017	34,500
41	S	0.702	0.065	32,500
42	S	0.738	0.029	34,000
43	S	0.750	0.017	34,000

*Difference in diameters.

14 No. 19 is a card taken while punching a $\frac{1}{2}$-in. plate of mild steel with a $\frac{3}{4}$-in. flat punch on the Bisbee-Endicott machine. This illustrates the effect of a small clearance on the force required to remove the bur, as the difference in diameters of punch and die was but 0.017 in.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE (III)

ARTICLES IN PERIODICALS

Auto-Motor, Test of a Franklin Air-Cooled, Evans and Lay. *The Automobile, March 31, 1910.* 5 pp., 1 table, 18 curves. *cf.*

Work done in 1907 at Sibley College. Tests in terms of different speeds, different timings of exhaust valve and different materials for air-fins.

Blast Furnace Gas Power Practice, H. J. Freyn. *The Iron Age, June 23, 1910.* 8 pp., 5 figs., 1 table, 6 curves. Also *The Gas Engine, August 1910.*

Operating experiences in South Chicago works of the Illinois Steel Co.

Box Coil Connection, E. Q. Williams. *Gas Power, September 1910.* 1¾ pp., 1 fig.

Explaining connections which are found in a box coil which are usually covered by wax.

By-Product Coke-Oven, Collin Regenerative, C. L. Lomax. *Progressive Age, July 1, 1910.* 1½ pp., 2 figs., 1 heat diagram. *b.*

Interesting record of current progress in German practice.

Calorific Power of Gas in Wisconsin Cities, Burgess and Huddle. *Progressive Age, April 1, 1910.* 2½ pp. *Statistical.*

Calorimetry, Report of Committee of American Gas Institute On. *Progressive Age, February 1, 1910.* 9½ pp., 1 fig., 11 tables, 5 curves.

Should be read in connection with the earlier reports by the same committee antedating this index. See also editorial on Heat-Units Requirements in same paper, February 15, 1910.

Cylinder Computations, C. M. Raymond. *Gas Power, September 1910.* 1 p.

Rules and ratios for finding sizes, etc., of cylinders.

Engine, 18-B. h.p. Portable Suction-Gas. *The Engineer (London), July 15, 1910.* ⅔ p., 2 figs., 1 table. *bC.*

Description of a portable suction-gas engine to do same work and fulfil same conditions as the portable steam engine.

Distribution Problems, High-Pressure Gas, H. L. Johnson. *Progressive Age, April 1, May 16, June 1, 1910.* 5 pp. *f.*

Paper before Illinois Gas Association with discussion. Concerns itself with practical details of construction.

Engine Economy, Notes on Gas, P. F. Walker. *Power, June 7, 1910.* 3 pp., 1 table, 5 curves, 20 indicator cards. *c.*

Investigation of influence of richness of mixture upon efficiency at different compressions, made by two students at University of Kansas.

Engine Installation, A Notable Gas. *The Iron Age, March 17, 1910.* 2 pp. *bf.*

Gas-driven blowing engines operating on furnace gas at Carnegie Steel Works, Youngstown, Pa. These 4 gas engines are driven by gas from blast furnaces and deliver blast to the furnaces. Each engine has a rated capacity of 40,000 cu. ft. of air per min. at 18 lb. pressure and 59 r.p.m.

Engine, New Two-Cycle Automobile. *The Automobile, March 31, 1910.* ½ p., 1 table, 12 indicator cards.

Brief abstract of tests made at Columbia University.

Engine Plants, Utilizing Waste Heat from Gas, John T. Faig. *The Gas Engine, July 1910*; also *March 1910.* 3 pp., 3 figs., 1 table.

Paper before the National Gas and Gasoline Engine Trades Association Cincinnati, June 15, 1910.

Engine Practice, Blast Furnace Gas, W. E. Snyder. *The Gas Engine, October 1910.* 5 pp.

Paper on gas engines in Europe, by H. J. Freyn before the Society.

Engine, Progress in the Diesel, E. D. Meier. *Power, May 31, 1910.* 2 pp., 1 fig. *ad.*

Abstract of paper before the National Association of Cotton Manufacturers. Discussion of costs of various powers and list of applications of Diesel engine.

Engines, Air Supply to Gas, W. E. Dalby. *Engineering (London), September 9, 1910.* 1½ pp., 1 fig., 3 tables, 2 curves. *ceB.*

On direct measurement of air supply to a gas engine by means of an orifice and the calibration of the orifice.

Engines for Driving Alternating-Current Generators, Gas, H. G. Reist. *The Gas Engine, August 1910.* 1½ pp.

Explanations of driving alternating-current generators with gas engines.

Engines, Ignition in Gas and Gasoline, Carl Pfanstiehl. *The Gas Engine July 1910.* 7 pp., 1 fig. Also *Gas Power, August 1910.* 3 pp.

Paper before National Gas and Gasoline Engine Trades Association, July 1910. Treats in general sparking devices for gas, oil and gasoline engines.

ENGINES, LARGE GAS, J. D. Lyon. *The Gas Engine, July 1910.* 6 pp., 4 figs.

Paper before the National Gas and Gasoline Engine Trades Association, Cincinnati, June 15, 1910.

ENGINES, MODERN ROLLING-MILL STEAM, E. G. Sehmer and R. Drawe. *Engineering News, June 16, 1910.* 1¼ pp. *f.*

Of importance in connection with the introduction of gas power into steel mills. The article was elicited by recent attempts with gas-electric power and auxiliary low-pressure steam turbines, without consideration of recent progress in steam reciprocating engines for this purpose.

ENGINE, SINGLE-STROKE, Consul Benjamin F. Chase, of Leeds. *United States Consular Reports, May 1910.* 1 p.

For automobiles, etc. Two impulses per revolution per cylinder. No mechanical description is given, but the report is on file in Washington, Bureau of Manufactures, with illustrations.

EXPLOSIONS COMMITTEE, THE GASEOUS. *The Engineer (London), September 23, 1910.* 1 p. *b.*

Editorial on work of Gaseous Explosions Committee of British Association.

EXPLOSIONS, GASEOUS. *Engineering (London), September 9, 16, 30, 1910.* 6½ pp., 1 fig., 2 tables, 6 curves. *cA.*

Third report of committee presented to British Association at Sheffield.

EXPLOSIONS IN TUBES, PROPAGATION OF, Chas. E. Monroe. *Proceedings, American Philosophical Society, July 1910.* 4 pp., 1 table. *c.*

Stove-naphtha, vapor and air experiments in connection with explosions in sewers of Penn. R. R. yard at Sheridan, Pa.

FACTORY PLANT, AN INTERESTING GAS POWER, Osborn Monnett. *Power and the Engineer, September 20, 1910.* 4½ pp., 6 figs.

Up-to-date installation.

GENERATORS, MANAGEMENT OF WATER-GAS, John F. Wing. *Progressive Age, May 16, 1910.* 5½ pp., 6 figs., 11 tables.

Paper describing the Everett works, before New England Association of Gas Engineers with discussion.

INTERNAL-COMBUSTION ENGINES FOR MARINE USE, W. R. Cummins. *Transactions, Institute of Marine Engineers, August 1910.* 22 pp. *f.*

Paper is of chief value as an indicator of progress in interest in this topic. The best technical value lies in the discussion, particularly that by O. Sumner, R. N. R., who read a paper on this topic as early as 1901.

INTERNAL-COMBUSTION ENGINES, PROPULSION OF CARGO BOATS BY, R. M. Neilson. *Cassier's Magazine, August 1910.* 8 pp., 3 figs. *a.*

Second half of an article devoted to freight-ship propulsion in general, including discussion of reciprocating turbine, combines and superheating plants.

Iron Horse, The, L. W. Ellis. *Gas Power, August 1910.* 2 pp.

Showing recent developments from early ideas.

Motor Contests, Winnipeg. *The Gas Engine, September 1910.* 6 pp., 3 figs., 2 tables.

Summary of competitive tests of 17 agricultural engines for ploughing, traction, etc.

Motor Trials, French Kerosene. *The Gas Engine, October 1910.* 5 pp., 1 table.

Abstract of competition before a fisherman's aid society among five makes of kerosene-engines.

Motor With Rotary Intake-Valves, New (Deloche) Two-Cycle, W. F. Bradley. *The Automobile, July 28, 1910.* 1½ pp., 9 figs. *b.*

Oil-Gas in California, Development of, E. C. Jones. *Progressive Age, May 2, 1910.* 8½ pp., 8 figs., 21 tables, 1 curve. *bdf statistical.*

Paper before American Gas Institute, Detroit, October 1909.

Pound, Stopping a Troublesome, A. E. Walker. *Power and the Engineer, October 11, 1910.* ½ p., 1 fig.

Pounding of an unknown origin located by chance.

Power, Possible Uses of Waste Gas, I. V. Robinson. *Power, April 26, 1910.* 1½ pp.

Abstract of paper before West of Scotland Iron and Steel Institute. Chiefly a discussion of costs and values.

Power, Recently Reduced Value of Water. *Engineering News, June 23, 1910.* 1½ pp. *a.*

Editorial reviewing broadly in terms of total relative cost, water, steam and gas power, as affected by recent engineering history.

Power from Peat, Generation of, T. A. Mighill. *The Gas Engine, October 1910.* 3 pp. Also Presidential Address, American Peat Society, June 28, 1910.

Abstract of paper before the American Peat Society at Ottawa.

Pressures, Varying Gas, W. A. Tookey. *The Gas Engine, August 1910.* 2 pp.

Shows differences in regulation owing to raising or lowering of pressure.

Producer Adapted to Heating (by Hot Water), Gas, F. P. Peterson. *Power, June 14, 1910.* ⅔ p., 1 fig. *f.*

Simple suggestion bearing upon an important problem in applying gas power to mill driving.

PRODUCER FOR BITUMINOUS COAL, DOUBLE-ZONE GAS, E. F. Bulmahn. *Metallurgical and Chemical Engineering, March 1910.* 2½ pp., 3 figs., 1 table, 1 curve. *bcf.*

Tests on various coals and lignites reported in a paper before Engineers Society of Western Pennsylvania.

PRODUCER-GAS POWER PLANTS IN THE UNITED STATES, R. H. Fernald. *Engineering News, May 5, 1910.* 1 p. *bf.*

Paper abstracted from United States Geological Survey, Bulletin No. 416. Data collected from 500 plants in the United States ranging from 15 h.p. to 6000 h.p. per plant.

PULSOMETER (PUMP), GAS. *Progressive Age, January 1, 1910.* ¾ p., 1 table. *bcfA.*

Paper quotes Gas World (London), November 6, 1910. Explosions occur directly against the water.

PUMP, HUMPHREY GAS. *Engineering (London), July 22, 1910.* 3 pp., 5 figs., 1 table, 1 curve. *bcB.*

Description of this interesting pump at the Brussels Exhibition.

PUMP, THE INVENTOR OF THE DIRECT-ACTING EXPLOSION, Wm. H. Smyth. *Engineering News, May 19, 1910.* 1½ pp., 2 figs.

Continuation of the discussion as to the true origin of this device. Mr, Smyth, American, contends with Mr. Humphrey, Englishman.

REMINISCENCES OF EARLY DAYS, SOME, A. E. Walker. *Power and The Engineer, September 26, 1910.* ½p.

Old-style starting devices compared with modern methods.

SMOKE PROBLEM, RELATION OF THE GAS PRODUCER TO THE, R. H. Fernald. *The Gas Engine, August 1910.* 2½ pp.

STEEL WORKS, POWER AVAILABLE IN. *Power, August 2, 1910.* 1 p., 2 figs.

Abstract of paper before Birmingham Association of Mechanical Engineers. Excellently clear diagrams of heat distribution in blast-furnace and coke-oven plants.

SUCTION-GAS PLANTS, DUTCH MARINE, F. Muller van Brakel. *International Marine Engineering, October, November 1909; April 1910.* 6½ pp., 6 figs., 9 tables. *bf.*

Describes practice which has grown up in close contact with the use of gas-power barges of unmechanical skippers without engineers. Also a gas-driven dredge.

SULPHUR COMPOUND IN ILLUMINATING GAS, Chas. R. Rumsburg. *Progressive Age, May 16, 1910.* 7 pp., 6 figs., 1 table.

Paper before American Gas Institute at Detroit, October 1909, with appendix and discussion.

TURBINE, INHERENT DIFFICULTIES OF THE GAS, R. C. H. Heck. *Power, May 3, 1910.* $2\frac{1}{4}$ pp., 7 figs.

Discussion of the basic thermodynamic considerations involved in cycle of air as compared with that of steam.

TURBINES TO AIR COMPRESSOR, APPLICATION OF LOW-PRESSURE STEAM, J. W. Shepardson, *Engineering Magazine, May 1910.* 14 pp., 2 tables, 9 curves.

Of interest in connection with the problem of gas turbine.

TURBINE, SOME PROBABILITIES OF THE GAS, Sidney A. Rieve. *Power, July 12, 1910.* $\frac{2}{3}$ p.

Discussion of fundamental conditions of gas-turbine design.

WARSHIPS, PROPELLING MACHINERY OF, H. J. Oram. *American Society of Naval Engineers, No. 1, 1910.* 5 pp. *f.*

Excellent brief statement by one of those whom marine gas-power propulsion must satisfy giving general accomplishments of steam power which must be excelled.

GAS POWER SECTION

GAS POWER DEVELOPMENT

By James Rowland Bibbins, Mem. Am. Soc. M. E.[1]

Chairman for 1910

In looking over the past year, we may ask ourselves, first, what has been accomplished, second, what forces have retarded development, third, what developments are probable in the near future, and fourth, how can the Section assist in the work? Your retiring Chairman confesses to a desire to grow reminiscent in his declining hours, and would remind you that this privilege comes with the honor of being associated with the work of this active Society in the year 1910, truly a census year. If we are looking for mile stones with which to chronicle our progress we may surely find them today; and a further reason for introspection is afforded by the fact that the Gas Power Section has completed its third year of existence, a period long enough to indicate whether the current of contemporary opinion is with or against us; whether we have achieved a healthy measure of success or have simply been marking time.

DEVELOPMENT

What has been accomplished? As to the Gas Power Section, sufficient, in my opinion, to guarantee the future. At the opening of the present century, many were the prophecies of epochal development in all branches of the technical arts. I believe the decade has fulfilled its promise. First, by way of comparison, we find the steam turbine grown from 300 to 30,000 h.p., with practice both in Europe and America gravitating toward a combination of the two principal types. We find single boiler units increased from 300 to 3000 h.p.; the steam engine, then fully developed, now endowed with a new lease of life through association with its erstwhile rival; and the electric generator literally decimated in bulk but still larger than its turbine.

[1] Address of the retiring Chairman at the Annual Meeting.

In the field of gas power, too, there is measurable progress. In size, engines developed from the single-acting units of 100 h.p. or so, to the double-acting tandem units of 4000 or 5000 h.p. designed for and operating under the same conditions as steam equipment, including the parallel operation of alternating-current generators. We find the steel-casting industry, then comparatively undeveloped, now able to turn out intricate one-piece gas-engine cylinders with jackets attached and crank discs with integral pins of the same material. We find producer units developed from a diminutive 10–50 h.p. up to 1000 h.p. or more and the problem of bituminous fuels well along toward solution, practice tending in the direction of the induction type for both large and small units, with self-contained vaporizer and continuous service. Opinion is somewhat divided as yet on the tar question, but all efforts are directed toward the abolition of this undesirable by-product by gasifying it.

Industrial Applications. But in its varied applications, the direct combustible principle has indeed achieved success. It is obviously no exaggeration to say that the gas engine has made possible the submarine, the aeroplane, the motor boat and the automobile. The aeroplane motor offers an object lesson in the results of high rotative speeds. The 30-h.p. motor of the Wright aeroplane weighs but $6\frac{2}{3}$ lb. per h.p. while the Darracq motor of about the same size, built for Demoiselle, weighs $3\frac{1}{4}$ lb. per h.p. The Gnome engine with radial rotating cylinders weighs still less.

Concerning the much-discussed problem of conservation, I need only refer to the utilization of blast-furnace gas, by-product coke oven gas, by-product oil gas from refineries and various low-grade or by-product fuels unsuited for steaming purposes. A large power plant is now being built to use waste cupola gas which, in heat value, runs about 50 B.t.u. and requires 300 lb. compression. The importance of these developments in solving the smoke problem, the power problem of our specialized manufactories and in deferring that national crisis, the extinction of fuel supply, cannot be overestimated.

On the one hand, the gas driven pump by reason of its high efficiency has found adoption in water works, sewage disposal, hydraulic excavation and long-distance gas transmission. On the other hand, by reason of the absence of stand-by losses it is equally desirable in emergency service, such as fire protection, hydro-electric auxiliary plants and canal lock operation. The coincident and related development of producers has brought about a revolution in such operations as hardening, tempering, melting, soldering, baking

and cloth singeing and especially the displacing of the supposedly indispensable Bessemer converter by the open-hearth furnace in single units of 400 tons or over.

Gas Engine. The development of the heavy-duty double-acting gas engine has been accompanied by certain interesting features, which while not universal, yet find quite wide acceptance in American designs. Foreign center-crank designs have been generally departed from in the use of the side-crank self-adjustable bearing construction. Experience has been gained with various cylinder materials, all steel or iron, steel walls only, cast-iron liners, both iron and steel pistons and with steel on steel. The trouble predicted with the latter does not seem to have materialized, as the gaging of piston clearances at any time is a simple matter. Krupp builds thin walls with longitudinal reinforcing tension rods while other foreign builders design cast-iron walls as thick as 3 in. Dry metallic packing has been substituted for the elaborately water-cooled style. Fads in valve gear are rapidly disappearing and the mechanism has been simplified by driving both inlet and exhaust valves from a single cam. In early practice the regulator was driven from any convenient point along the camshaft, but is now driven directly from, or at a point close to the main shaft so as to avoid cyclic torsional effects in the camshaft. Direct governing has largely been replaced by the relay type using drop cut-off or positive oil pressure to move the valves. This has permitted the use of a very small regulator, usually on the German straight-line principle, as represented by the Jahns and Hartung design, the weights moving directly against spring pressure. Mixing is now done only at the inlet valves, thus minimizing the result of a back-fire. By the symmetrical distribution of gas and air with reference to the four inlets, non-uniform mixing due to unequal fluid inertia effects have largely been overcome. The electro-magnetic igniter has found much favor by reason of its simplicity, and has made possible ignition at several points in the combustion chamber, bringing more rapid as well as surer combustion with lean gases. A series system of circulation has reduced the water consumption and also the troubles from sweating of cold rods with high sulphur gas. The foreign practice of cambering rods is entirely disregarded here, for with light, one-piece pistons, the rod flexure is not greater than considered desirable to keep the sectional packing free. And, finally, centralized continuous return lubricating systems are the rule for engine oil, with timed force feed for cylinder oil, this latter replacing all attempts

at graphite lubrication or indiscriminate injection of oil during combustion.

The special adaptation to direct connection with reciprocating compressors has brought about the variable-speed long-stroke gas engine (of two diameters or more). These are operated in the natural gas districts of the Central and Western states. One company alone has 24 of these units in service of about 1300 h.p. each. An interesting feature brought out by some recent tests by the author is that for the same power output the gas and heat consumption is not widely different at full or reduced speeds and about the same as an electric engine of normal proportions.

A moderate-sized double-acting engine has also come into use. It has a stroke of about 2 ft. and its high rotative speed, 200 r.p.m., is of great advantage in direct-connected electric drive.

The gas-electric motor car is another interesting development which has been under investigation for several years by railroads for service on extensions or suburban branches where regular steam equipment has not been justified. These cars are self-propelled by a compact 8-cylinder high-speed generating set located in the cab, and standard electric-motor control. Sixty-seat coaches ordinarily make an average schedule speed of 25 mi. per hr. including stops. Demonstration runs have resulted in a gasolene consumption of 0.36 to 0.48 gal. per car-mile. A single truck car of this type has been on trial for cross-town service on some of the lines in New York City not yet electrified.

So much for progress and accomplishment. The evidence exists throughout the land from the thousands of small engines upon the hillsides of the Pennsylvania oil fields to the great installations at Gary, Buffalo and Pittsburgh, in the Mexican highlands with a central station burning mesquite, in Texas with its lignite, in Canada with its peat, in the Nevada ranges with a mining plant of Diesel oil engines, in Nova Scotia and Buenos Ayres which are running railroad shops, in Ohio with its boosting of gas to Cleveland, in the watering of the Imperial Valley reclamation in Arizona, in Philadelphia and Coney Island with their high-pressure fire protection systems, and in Pittsburgh with its operation of the locks of the Ohio canalization project. This is admittedly a good record but we should never be guilty of that smug satisfaction that blinds us to minor shortcomings. So let us glance at some aspects and causes of retarded development.

RETARDATION

A very serious handicap in industrial work is the present inability of the gas power system to accomplish factory heating in lieu of exhaust steam. This is particularly serious in the Northern states and in Canada. Unfortunately the high efficiency of the gas engine is lost in comparison with the "steam eater" desired in a heating plant. Some progress is being made with the manufacture of exhaust heaters, but the available 5000 or 6000 B.t.u. per b.h.p. is not sufficient for heating a large factory. Some system of auxiliary gas-burning heater must be worked out with automatic temperature control to compensate for the variation in load. An attempt at conserving this sixty-odd per cent waste heat, now rejected, should be made so as to return the major part of it to the heat cycle. The gas engine is roundly scored for not having overload capacity for fluctuating peak loads. Now with an efficient regenerating heater operating in connection with a low-pressure steam-turbine auxiliary, it is possible largely to increase the output, or vice versa, the economy. I am glad to report that one of our manufacturers is working along this line on a projected plant.

We must have more convenient and practical methods of measuring power gas, both with respect to volume and especially to heating value. No sensible individual would attempt to operate a steam plant without a pressure gage, even neglecting the personal risk, but with gas we are working continuously in the dark and with engines equally sensitive to reduced potential as with steam. Some large plants have, of course, adopted the Venturi meter, but even this simple apparatus is sensitive to deposits in the throat. A continuous recording calorimeter is a great necessity and progress is being made in this direction.

There is a disposition to discount the demand for large units. both engines and producers. With turbine units increasing by leaps and bounds, the gas power industry must respond in kind if not in equal measure or remain an auxiliary for special conditions. The 44-in. by 60-in. cylinder is now in evidence. Let us have higher rotative and piston speeds with relatively shorter stroke and larger diameters if possible. The Lentz steam engine is a remarkable example in this respect. It is only to be expected that the production of special high-tensile steels and further perfection of foundry practice will make this possible. This improvement in engine construction will remove one of the causes of complaint in the past on

large engines, the failure of cylinders and pistons, due for the most part to shrinkage or temperature strains.

Nor can it be believed that the producer fuel bed has reached the limit of its diameter, and with a rate of gasification only 15 lb. per sq. ft. per hr. At this rate an 8-ft. producer would yield only 750 b.h.p. Marine and locomotive practice with induced draft succeeds with many times this rate. A full-grown power plant of today requires units of 3000 to 5000-kw. capacity with at least 2000-h.p. producers.

Finally, there is a lack of education not only on the part of operator but of salesman and manufacturer as well. The last-named is often the least wide awake, the first the most receptive of intelligent guidance. The great mistake is made in semi-education; first, an incomplete understanding of the conditions, second, a make-fit equipment, third, a jealous guarding of essential knowledge of defects. The result is loss of confidence, dissatisfaction, failure. When will we learn that to take the operator into our full confidence secures his allegiance for all time?

THE FUTURE

Marine Propulsion. This most important development looms big on the horizon. Much has been written of the producer gas system, but it must be confessed that the oil-burning engine is more attractive from the standpoint of convenience and compactness. The advantage of storing oil in the ship's double bottoms is great from a standpoint of cargo capacity. European countries have been active in this development: Russia with its tank ships, France with its submarines and the coast countries with their fishing fleets. Successful producer-gas equipments are to be found on some of the inland waterways of Europe, where coal is the cheaper fuel, and a boat is being equipped here for service in New York harbor.

Recently the announcement has come of the adoption of oil engines for the 8000-ton, 12.5-knot freight boats now being built by the Hamburg-American Line. These will be equipped with two 1500-h.p. Diesel engines built by the Augsburg and Nurnberg works, and if the experiment is successful, passenger vessels will be constructed. One American builder, at least, has taken up the Diesel engine for marine work.

Power from Crude Oil. The oil-engine development seems to have made great headway abroad since the expiration of the basic Diesel patents. Three of the principal companies have built 500,000-h.p.

with four and six cylinder units up to 2000-h.p. capacity per cylinder. The Diesel firm is building on this principle as small as 5–30 h.p. The smaller engines are mostly four cycle while above 1000 h.p. the two-stroke cycle prevails, which in an oil engine, works out much more simply than in a gas engine which requires a separate pump for both gas and air. Maximum compression is somewhat over 500 lb., with air injection at 600–850 lb. In most cases the compressors are built into the main unit and geared, not as a separate auxiliary. Some of the builders are reported to be developing double-acting designs for engines of high power.

In London, one of the electric supply companies has installed Diesel engines to supplement the transforming equipment of its sub-stations, using oil distillate at a cost per kw-hr. lower than that from the main stations. A somewhat similar type of plant in one of our Eastern cities is used to boost the potential of low points in a direct-current distribution system. The generator, however, is under-compounded so as to limit the output and thus equalize with other parts of the network. Obviously the oil engine is an ideal prime mover for this work.

In the various experiments with oil-gas producers, the small progress has been discouraging. Two systems have been used, the retort and the partial combustion. In the former, difficulties with carbon deposition in the retorts are encountered; in the latter, excessive production of lamp black. Both are hopelessly low in efficiency as compared with oil-burning steam plants. A large oil-gas plant, in California, operating gas engines as water power auxiliaries, endeavors to apply to power purposes mixed gas, consisting of part retort and part carburetted water gas, utilizing the carbon deposits of the former as bricquettes in the latter process. In this mixed gas, the hydrogen content is kept down to about 30 per cent, but in the oil-gas it is very much higher, 40–60 per cent. For straight power purposes the combustion producer seems more promising, both in simplicity and efficiency. The Imperial Valley project is being served by a small lift station of this type at Yuma, Arizona.

Power in the West. Closely related, is the development of the western power fields, both for irrigation and for mining operations. The Easterner cannot realize to what extent irrigation has taken hold of the West and what a field there is for power pumping if we can only develop it. Utah, Arizona, Texas and the Great Plains embrace broad areas underlaid by basins of hard pan yielding ground waters, which vary in depth from a few feet in favored areas to 50 or 75 ft. in

others. At present, electric power pumping is predominant. John C. Hays,[1] in discussing a California installation, an area of 1050 sq. mi., 86 per cent of which is electrically irrigated, declares there is no reason why this field should not be open to gas-power pumping. One installation is already projected with gas-driven generators, but why not direct pumping? No one familiar with the ever-present gas pumpers of the oil fields will fail to see the parallel. But we must have a low-priced engine, simple, "fool-proof", and preferably of a high-speed multi-cylinder type adapted to direct connection to centrifugal pumps. Present types of high-speed engines are not readily adaptable to rotary pumps because of the disparity between impeller proportions and engine speed, although a few sizes can be found suited to low-head work. The new Humphrey gas pump is evidently suited to the service, in fact, it is already operating in India in irrigation enterprises. Recently a unit as large as 25,000,000 gal. was contracted for. This pump utilizes the water column itself as a piston and is approximately "fool-proof".

A crude oil engine is obviously a necessity in the far West. East of the Rockies, a lignite suction producer in small sizes would find application, but in California oil predominates. In 1908 the production was 48,300,000 bbl. at an average price of $0.54 per bbl. The majority of this was asphaltum base oil, 12 to 17 deg. Baumé being used for oil-gas generation.

In the mining districts, we find wood, charcoal and black lignite used for steaming purposes, even where water is scarce and impure. One plant, however, accepted the situation and installed Diesel engines with a continuous closed fan-cooling system for jacket water.

The development of lignite deposits in the middle West is encouraging. In 1907, the output west of the Mississippi was 5,000,000 tons, of which Colorado produced one-third, with Wyoming and Texas next in rank, with an average price of $1.55 per ton as compared with $1.12 for all bituminous coal mined in this country. This price does not of course apply to the more inaccessible regions where fuel costs $4 to $8 per ton. Here in the West is indeed an opportunity.

Canada. We have looked to Canada for important developments in the use of peat, but private experiments have failed so signally that the Government has started a peat manufacturing and power plant to demonstrate the process on a commercial scale and reëstablish confidence in this industry. Director Haanel of the Bureau of

[1] Proceedings Am. Inst. E.E., May 1910. The Mt. Whitney Power Co.

Mines thus summarizes his investigations: Artificial drying processes have failed commercially and a machine process must be substituted for manual labor. The department is therefore proceeding along European lines of established success. He states that Russia alone produced 4,000,000 tons of peat fuel in one year, 1900. Peat containing not over 25 to 30 per cent water has been found an ideal fuel for gas producer work requiring no further vapor and is quite free from high temperature and clinker. The long series of fuel tests at Montreal have served to confirm the results of our Government tests on lignites in demonstrating the great possibilities of these lignite deposits, especially in the Canadian North West.

Self-Starting Engine. No real progress is apparent in the self-starting gas engine. Some automobiles are equipped with small compressed-air motors, but at considerable expense. No simple combustion method has yet appeared. The opportunity is clear. On very large units, one builder employs for starting an explosive mixture compressed to about 80 lb. and stored in the same manner as the usual compressed air. Some trouble has been experienced in guarding against back-fires into the storage tank.

Double-Deck Stations. In large cities where land is dear a new style of power plant would seem to have some possibilities. The double-deck type with the producer plant above has some advantages over the familiar double-deck turbine plant in that the building steel work would be designed for a dead load, concentrated along the supporting walls where the producers would naturally be located. I am not sure of the comparative costs, but the economy in space in a large plant works out relatively low.

UNDEVELOPED FIELDS

Engineering Economies. Returning now to a consideration of some of the broader aspects of this subject, it seems to me that there are some fruitful fields still undeveloped. Engineering today has become not entirely a technical, but an economic science as well. We must not only ask the question, will it work, but first and foremost, will it pay the proper return on the investment. Consider for example the total cost of power production. How much earnest effort has been thrown away in fruitless discussions of mere operating costs, technical finesse, when the language of fixed charges, depreciation, obsolescence, supercession and business risk had not been fully learned. This phase of gas power development has been serious in

the past and is undoubtedly responsible for many of the failures on record. Such problems continually arise in the course of comparative studies of gas producer and turbine plants with various load factors and prices of coal. The success of the by-product coke-oven industry in realizing profits from its by-products, rests solely upon the economics of the case, and abruptly raises the question, which is the major product, gas or coke. The analysis of the cost of production is far more important than that of microscopical improvement in efficiency.

Technical Consular Attaché. No one can deny the great value of detailed knowledge of the development of the arts in foreign countries. Private individuals or corporations constantly invest large sums in securing such information for their purposes. Now in view of the extended activity of our Government along scientific and commercial lines as evidenced by the Geological Survey, the Bureau of Mines, the Bureau of Standards, and the Smithsonian Institution, does it seem unreasonable to broaden the usefulness of our consular service by the establishment of a new function, a technical investigating staff whose duty it would be to keep constantly before American engineers the more important achievements of foreign contemporaries? The excellent report on Peat and Lignite by the Canadian Bureau of Mines is a case in point. The fact is that progress today is so rapid that no individual can hope, unaided, to keep abreast without expending more time than is available in general investigation that should properly be detailed to special talent. And it seems to me that the national engineering societies should be the leaders in fostering this activity.

Coöperative Research. The movement toward the coöperation of the engineering fraternities with the educational institutions should be encouraged, by the more widespread establishment of technical apprenticeships in our shops and offices. It is no exaggeration to assert that today the technical graduate furnishes the new blood of industrial enterprise. His training and his ideals form the groundwork of a steadily improving standard in commercial life. By the same token the colleges have a right to expect coöperation. Their costly laboratories are at our disposal for the asking. We spend millions in commercial experiments that can at least yield only approximations. Many of these investigations should be transferred to the laboratory.

There is now before the technical institutions of the country a comprehensive list of subjects needing scientific investigation, many

of them of the utmost importance. Could we persuade the manufacturers of the country to endow graduate fellowships in their chosen fields with ample funds for defraying the material costs of such investigations, the return on their investment, I believe, would be well above the market rate of interest. A few progressive concerns have taken this step, but they may be regarded only as a precedent. One technical institution has itself provided an endowment. Interest the student in your business by affording him some incentive and he will become a loyal apprentice, an effective salesman and a competent executive. I beg to suggest that this Section take more definite action through the Society, along these coöperative lines. As subjects, I need only mention the following as typical.

a Maximum efficient rate of combustion in producers as effected by width and depth of fuel bed, rate of blast, moisture content and character of fuel.

b Study of chemical reaction in the fuel bed to determine the conditions for suppressing the formation of tar or lamp black and securing maximum percentage of combustibles in gas together with high overall efficiency.

c Study of the relative jacket absorption with varying time contact due to different combustion chamber and cylinder proportions, and piston speeds.

d Effect of auxiliary precompression of charge on efficiency and power of gas engines with reference to securing unlimited overload capacity.

e Determining of most suitable form of gas engine indicators to standardize accurate methods of working.

f Research work on maximum heat values of combustible mixtures standardizing formulae for the standard reference cycle.

It seems to me that the progressive spirit of the true investigator is well expressed in a little quatrain of Rudyard Kipling, Initiative and Leadership. It runs thus:

> "They asked him how he did it and he gave 'em the Scripture Text,
> You keep your light so shining a little in front of the next.
> They copied all they could follow but they could not copy his mind,
> And he left them sweating and stealing a year and a half behind."

The answer is, initiative pays. Anybody can follow.

Work of the Section. Finally, as to the work of the Gas Power Section, the interest manifested in the last few meetings indicates that it has been productive of results. Out of 180 papers presented to the Society within the last five years, 24 have been devoted to gas

power or related subjects; two committees have presented comprehensive reports, and a third its detail work from time to time. Although none of the committees now at work have reported conclusively, their preliminary reports have furnished an ample basis for further action. Possibly the most pressing need is the standardization of tests and efficiency determinations. These matters were brought to the attention of the Society in concrete form by the Standardization Committee of this Section and are now in the hands of the Power Test Committee of the Society.

The greatest value, therefore, of the Section rests in the contributions to the art in the papers or reports presented. We should not glory in mere numbers, but on the other hand, excessive concentration in the choice of subjects does not effectively reach the full membership. We may well accept the two contributions on blast furnace practice as an earnest of our desire for contributions of the highest possible standard. I have heard Lord Bacon quoted on this theme: "I hold every man a debtor to his profession from the which, as men, of course, do seek countenance and profit, so ought they of duty endeavor to be a help and ornament thereto." This seems sound doctrine and in the belief that it will not fall on arid ground, I look for the continued growth of this membership with the very keenest interest.

GENERAL NOTES

AMERICAN SOCIETY OF CIVIL ENGINEERS

At the December 7 meeting of the American Society of Civil Engineers, papers were presented on Bond-Friction Resistance in Reinforced Concrete, by William Fry Scott, and on Hydrography as an Aid to the Successful Operation of an Irrigation System, by J. C. Stevens. On December 21, the papers discussed were Notes on the Bar Harbors at the Entrance to Coos Bay, and Umpqua and Suislaw Rivers, Oregon, by Morton L. Tower, and Timber Preservation, its Development and Present Scope, by Walter Buehler. On January 4, Henry Earle Riggs will present his paper on The Valuation of Public Service Corporation Property.

The Society will hold its annual business meeting on January 18 and 19 at its headquarters on 57th Street, which will be the occasion of the annual reports of the election of officers for the ensuing year, amendments to the Constitution, and other matters of a similar nature. On January 20 and 21 special meetings will be held for topical discussion on the general subject of Road Construction and Maintenance, with particular attention to the relative value of the three methods of carrying on this work, the systems of maintenance, and dust palliatives, surface treatment, and penetration and mixing methods. All engineers interested in road building are invited to be present.

For the trip to be made to the Isthmus of Panama in March, the society has chartered two steamers from the United Fruit Company, one of which will leave New York on March 2, returning on March 24, and the other leaving New Orleans on March 4 and returning to that city on March 21. Both will go directly to Colon and after a brief stop proceed on the cruise, stopping again on the return route. Reservations must be individually secured from the company before January 15.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

At the monthly meeting of the American Institute of Electrical Engineers, to be held in the auditorium of the Engineering Societies Building on January 13, the general subject will be Corona, on which two papers will be presented by Prof. Harris J. Ryan, one entitled Atmosphere in the Open and Dry Transformer Oil as High Voltage Insulators, and the other, A Power Diagram Indicator for Use in High Tension Circuits.

AMERICAN INSTITUTE OF MINING ENGINEERS

The annual business meeting of the American Institute of Mining Engineers will be held on February 21, 1910. At this meeting there will be the annual election of directors, and the transaction of other business, including a report of the financial condition of the Institute. Following this meeting there will

be a session for the presentation and discussion of technical papers, which will probably be held in some city in the East.

CEMENT EXHIBITION AND CONVENTIONS

Two conventions, one the seventh annual convention of the National Association of Cement Users, held at Madison Square Garden, and the other the annual meeting of the Association of American Portland Cement Manufactures, held at the Hotel Astor, as well as the first annual New York Cement Show, which opened in Madison Square Garden on the evening of December 14, brought many men representing cement interests to New York during the week of December 12.

In the exhibition, which was opened by Mayor Gaynor of New York on Wednesday evening, 250 firms participated, covering every available square foot of space, in the exhibition hall. The cement house designed by Thomas A. Edison and also the house which won first prize at the recent convention for the prevention of tuberculosis were among the prominent displays. Many foreign exhibits in cement progress were also included, giving the whole an international aspect.

Among the prominent speakers at the two conventions were Calvin Tomkins, commissioner of docks and ferries; Col. J. Hollis Wells; Dr. Walter Page, director of the Agricultural Department, Washington; Charles Wisch, chief municipal architect, Cologne, Germany; E. P. Goodrich; John Purroy Mitchell, president of the Board of Alderman, New York; John Carrere; Charles Battell Loomis, Robert W. deForest, John R. Morron, Benjamin D. Traitel, and Robert W. Lesley. The Civil Engineers' Societies of France and Germany and the Cement Association of Great Britain were officially represented at the meetings.

INTERNATIONAL EXHIBITION OF MECHANICAL EQUIPMENT

An international exhibition of mechanical equipment of all sorts and of the novelties and patents of the iron and engineering industry is to be held at Industry Palace, Budapest, Hungary, in May and June, 1911, under the direction of the National Association of Hungarian Ironmongers and the Royal Board of Trade of Hungary. The exhibition has for its object the dissemination among the engineers and manufacturers of Hungary information regarding machines for industrial and agricultural purposes, steam and gasoline engines, refrigerating plants, mining machinery, etc., and patented equipment for various other purposes. American manufacturers are invited to display their products.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The third annual meeting of the American Institute of Chemical Engineers opened on Wednesday, December 7, in the Hotel Astor, New York, with a business meeting and papers on the Development of the Chemist as an Engineer, by Dr. Fred. W. Atkinson, of Brooklyn; The Training of Chemical Engineers which Meets the Requirements of Manufacturers, by Prof. M. C. Whitaker, New York; The Fitzgibbons Boiler, by Jerome Alexander. In the afternoon an excursion was made to the Marx and Rawolle Glycerine Refinery in Brooklyn. The evening

session held at Columbia University included an address of welcome by Prof. M. T. Bogert, the address of the retiring president, Chas. F. McKenna, and a paper on the Manufacture of Hydrated Lime, by Richard K. Meade. Thursday was devoted to excursions to the chamber acid plant of the Standard Oil Company at Bayonne, N. J., and to the Borough of Richmond Garbage Destructor. A dinner at the Hotel Astor occupied the evening. The professional session of Friday morning was again held at the Astor and included papers on the Manufacture of Lignite Briquettes, by Henry W. Renaud; Bleaching Oils with Fullers Earth, by David Wesson; Action of Fruit Juices on Metallic Containers, by Edward Gudeman; and Vacuum Distilling Apparatus, by Philip B. Sadtler. Excursions were made in the afternoon to the candle house of the Pratt Works, Standard Oil Company, and also to the grease works of the same company, both located at Blissville, L. I. The evening meeting was a joint session with the New York Session of the American Chemical Society and was held at the Chemist's Club. Papers were read on the Principles of Sewage Disposal, by George C. Whipple; Sewage Disposal in Europe, by Rudolph Hering, Mem. Am.Soc.M.E.; Sewage Disposal in New York and Vicinity, by Dr. Geo. A. Soper; Sanitary Conditions in their Relation to Water Supplies in the Vicinity of New York, by Nicholas S. Hill, Jr.; and the Unsolved Problems of Sewage Disposal, by Prof. Chas. E. A. Winslow. Saturday was devoted to the inspection of the chemical museum and laboratories of Columbia University and of the College of the City of New York.

NEW JERSEY SANITARY ASSOCIATION

The program of annual meeting of the New Jersey Sanitary Association, held at Lakewood, N. J., December 2 and 3, 1910, included papers on Two Years Experience in Dust Suppression on Roads, by James Owen, Mem.Am. Soc.M.E.; Disposal of Trade Wastes, George A. Johnson; The Possible Deleterious Effects of Illuminating Gas upon the Human Economy, by C. E. Forstall and the presidential address on Latest Phases of Sewage Purification, by Rudolph Hering, Mem.Am.Soc.M.E.

NATIONAL COMMERCIAL GAS ASSOCIATION

The annual convention and exhibition of the National Commercial Gas Association, held in Boston, December 5–13 included papers on Manufacturers' Paper, Wm. T. Barbour; Industrial Fuel, A. V. Wainwright; Illumination, Norman Macbeth; Service, C. W. Hare; Rates, Henry L. Doherty, Mem.Am. Soc.M.E.; Compensation of Representatives, J. D. Shattuck; A Traveling Salesman's Views of the Commercial Department, H. L. Schutt; Lighting and Fuel Maintenance, F. J. Rutledge; Relations with Customers, V. A. Henderson. A banquet at the Hotel Somerset with trips to historical points of interest were arranged by the committee in charge.

MODERN SCIENCE CLUB

At the meeting of the Modern Science Club at its club house in Brooklyn, N. Y., on December 6, L. G. Benton of the Norben Oil Company gave an address on the Manufacture and Use of Lubricating Oils, and on December 13, Fred. R. Low, Mem.Am.Soc.M.E., Editor of Power and the Engineer, spoke upon Entropy.

PERSONALS

Frederic W. Bailey has become identified with the construction engineering department of the General Electric Co., Schenectady, N. Y. He was until recently associated with the Solvay Process Co., Syracuse, N. Y., in the capacity of draftsman.

C. W. E. Clark has resigned the position of steam engineer with the N. Y. C. & H. R. R. R. Co., to accept an appointment with the Stone & Webster Engineering Corporation of Boston.

Charles H. Delany has entered the employ of the Pacific Gas & Electric Co., San Francisco, Cal., in the department of operation and maintenance. He was formerly associated with the Babcock & Wilcox Co., Bayonne, N. J.

Charles H. Doebler has become master mechanic of the C. & O. Ry. Co. of Indiana, Peru, Ind. Until recently Mr. Doebler was general manager of the Lima Brake Shoe Co., Lima, O.

Wm. F. Gillies has become associated with the Ingersoll-Rand Co. of Texas, El Paso, Texas, in the capacity of secretary.

J. Howard Hayes has become connected with the turbine department of the Platt Iron Works Co., Dayton, O. He was formerly partner of the F. H. Hayes Machinery Co., Boston, Mass.

Fred. M. Hitchcock, formerly with the Ingersoll-Rand Co., New York, has been appointed executive engineer of the Dexter Folder Co., Pearl River, N. Y.

A. W. Patterson, recently associated with the Invincible Electric Renovator Sales Co., Boston, Mass., as manager, has become district manager of the Yale & Towne Manufacturing Co., New York.

L. R. Valentine has been transferred from the Security Cement & Lime Co., Security, Md. to the Charles Warner Co., Devault, Pa.

J. G. Vincent, recently in the employ of the Burroughs Adding Machine Co., Detroit, Mich., has accepted a position with the Hudson Motor Car Co. of the same city.

D. J. Whittemore has resigned as chief engineer of the Chicago, Milwaukee & St. Paul Ry. Co. and of the Chicago, Milwaukee & Puget Sound Ry. Co., to become consulting engineer of the former company, with office in Milwaukee, Wis.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society, included in the Engineering Library. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

AMERICAN CERAMIC SOCIETY. Transactions. vol. 12. *Columbus, 1910.* Gift of society.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Transactions. vol. 31, 1909. *New York, 1910.*

APPRECIATION OF THOMAS DAVENPORT. By T. C. Martin. Issued by the Vermont Electrical Association.

BACON IS SHAKE-SPEARE. By Edwin D. Lawrence. *New York, J. McBride Co., 1910.* Gift of author.

BAYLOR UNIVERSITY. Bulletin. vol. 13. no. 4–6. *Waco, 1910.*

CHICAGO TRACTION, BOARD OF SUPERVISING ENGINEERS. Second Annual Report, 1909. *Chicago, 1910.* Gift of Bion J. Arnold.

CONGRESO CIENTIFICO, 1st PAN-AMERICAN, CIENCIAS FISICAS. vol. 5, section 2. *Santiago de Chile, 1910.* Gift of the Congress.

DIE DIPLOM-INGENIEURE UND DER BEGRIFF "TECHNIKER" NACH DER GEWERBEORDNUNG. By Alex. Lang. (Sonderabdruck aus der Zeitschrift des Verbandes Deutscher Diplom-Ingenieure, pt. 22, 1910.) *Berlin, 1910.* Gift of author.

EFFICIENCY LIMITS IN THE POWER GAS PRODUCER. By W. D. Ennis. Reprinted from Transactions, vol. 2, of American Institute of Chemical Engineers.

FARADAY: HIS LIFE AND WORK. By W. F. Tucker. (Read at a meeting of the American Chemical Society, Nov. 6, 1908.)

HISTORY OF THE TELEPHONE. By H. N. Casson. *Chicago, A. C. McClurg & Co., 1910.*

INDIANA ENGINEERING SOCIETY. 30th Annual Report. *Indianapolis, 1910.* Gift of the society.

INSTITUTE OF ELECTRICAL AND MECHANICAL ENGINEERING, TRICHINOPOLY. Brief Narration on the Value of Education.

INSTITUTION OF GAS ENGINEERS. *Transactions. 1909. London, 1909.*

MANCHESTER STEAM USERS' ASSOCIATION. Memorandum by Chief Engineer, 1909. *Manchester, 1910.*

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION. Proceedings of the 41st Annual Convention, Reading, 1910. Gift of the association.

METAL WORKING PLANTS AND THEIR MACHINE TOOL EQUIPMENT. By Charles Day.

NATIONAL IRRIGATION CONGRESS. Official Proceedings of the 18th National Irrigation Congress. *1910.*

New York Central and Hudson River Railroad Company. Annual Report of the Board of Directors to the Stockholders. 1905–1909. *New York, 1905–09.*

New York City, Borough of Richmond. Annual Report 1902–1906. *New Brighton, 1902–06.* Gift of President of the Borough of Richmond.

New York, New Haven and Hartford Railroad Company. General Statement. 1900–1910. *New York, 1900–1910.*

Sending A State to College. What the University of Wisconsin is doing for its people. By Lincoln Steffens.

Smeaton's Reports. vol. 1. *London, 1812.* Gift of Henry R. Towne.

Southern Industries. The Tradesman Classified. Directory and Buyers' Guide for 1910. *Chattanooga, 1910.* Gift of Tradesman Publishing Co.

Text Book of Elementary Foundry Practice. By W. A. Richards. *New York, Macmillan Co., 1910.*

Virginia Polytechnic Institute. Bulletin. vol. 3. no. 4. October 1910. *Blacksburg, 1910.*

Wisconsin Engineer. vol. 15. no. 2. *Madison, 1910.* Gift of A. G. Christie.

EXCHANGES

American Society of Civil Engineers. Transactions. vol. 70. 1910. *New York, 1910.*

Cold Storage and Ice Association. Proceedings. vol. 1, no. 2; vol. 3, no. 1; vol. 4, no. 1–2; vol. 5, no. 1–2; vol. 8, no. 2; vol. 9, no. 2. *London, 1901–1904, 1909–1910.*

Institution of Civil Engineers. Minutes of Proceedings. vol. 181. *London, 1910.*

Master Car Builders' Association. Proceedings. vol. 44, 1910.

Worcester Polytechnic Institute. 41st Annual Catalogue. 1910–11. *Worcester, 1910.*

UNITED ENGINEERING SOCIETY

American Institute of Architects (Brooklyn Chapter). Year Book, 1910. *1910.* Gift of Brooklyn Chapter.

Annuaire des Journaux Revue et Publications Periodiques. 1910. *Paris, 1910.*

Deutscher Journal-Katalog. 1911. Leipzig.

Michigan Gas Association. Proceedings of 19th Annual Meeting, 1910. Gift of the association.

TRADE CATALOGUES

American Water Softener Co., *Philadelphia, Pa.* Water filters for office buildings, residences and institutions, 15 pp.

Earle C. Bacon, *New York City.* Hoisting engines and mining machinery, 134 pp.

Ball Engine Co., *Erie, Pa.* Steam engines, side crank type, 40 pp.

Berliner Maschinenbau Gesellschaft, *Berlin, Germany.* 4-4-0 superheated steam passenger locomotive, 12 pp.; Notes on superheated steam locomotives, 9 pp.; Ten-coupled, ten-wheeled superheated steam locomotives, 9 pp.; Six-coupled, eight-wheeled superheating express engine, 37 pp.; History of the Berliner Maschinenbau Gesellschaft, 46 pp.; Various types of locomotives, 63 pp. 4-6-0. four-cylinder superheated steam express locomotive, 14 pp.; Four-cylinder compound express locomotive of the Danish railways, 24 pp.

Bristol Co., *Waterbury, Conn.* Bull. no. 140. Recording gages for all ranges of pressures and vacuum, 47 pp.

Bush Steam Generator Co., *New York City.* Steam generators, 5 pp.

Gerard Development Co., *New York City.* Herrick balanced rotary engine report, 4 pp.

Leeds & Northrup Co., *Philadelphia, Pa.* New shop and laboratory, 12 pp.

Link Belt Co., *New York City.* Conveying machinery for sugar estates and refineries, 52 pp.; Conveying machinery for coal mines, 42 pp.; Peck carrier for coal, coke, ashes, cement, etc., 96 pp.; Conveyors for freight and packages, 64 pp.

Ohio Brass Co., *Mansfield, O.* Bulletin, Oct.-Nov., 1910, 22 pp.

Underfeed Stoker Co. of America *Chicago, Ill.* Publicity Magazine, December 1910, 16 pp.

Whitney Mfg. Co., *Hartford, Conn.* Roller chains and block chains, 38 pp.; Dimensions of Whitney chains, 40 pp.; Machine keys and key seat cutters, 24 pp.; Milling machine appliances, 16 pp.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

MEN AVAILABLE

154 Junior, graduate M.E., practical experience as inspector materials of construction; experimental steam engineer, superintendent of power plant. Now engaged as assistant master mechanic of large manufacturing concern. Desires position as assistant superintendent or manager of industrial plant or engineer-salesman of power plant equipment.

155 Graduate Columbia University, four years experience design, construction and testing of gasolene engines; desires permanent executive position with progressive concern in engineering or shop department, Eastern states preferred. Familiar with recent shop practice; successfully handled American and European skilled labor.

156 Member desires other engagement; sixteen years experience in modern blast steelworks and rolling mill machinery, gas engines, gas producers etc.; chief mechanical engineer, best of references.

157 Position desired as inspector with consulting engineer or firm contracting engineers. Five years experience as an erecting foreman. Speciality, railway engineering; age twenty-six. College training.

158 Young engineer, graduate Stevens Institute Technology; executive ability, experience in industrial engineering and factory management; specialized in power plant equipment, condensers and cooling towers, desires position leading to administrative responsibility.

159 Position desired as shop engineer, devising ways and means of doing work; experience as tool room foreman and designer of machines for various parts of product semi and full automatic.

160 Cornell University graduate in mechanical engineering, experience in the electrical field, engineering sales and executive branches of the profession specializing in elevating and conveying problems. Prefers position as engineer or manager with concern engaged in general engineering and contracting work.

COMING MEETINGS

January—February

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

December 27–January 3, Minneapolis and St. Paul, Minn. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

THE AMERICAN INSTITUTE OF ARCHITECTS

January 17–19, annual convention, San Francisco, Cal. Papers: The Development of Architecture on the Pacific Coast and the Rehabilitation of the City of San Francisco. The Aesthetic Problems of and what the Coast has Accomplished in City Planning, The Salient Points of the Architecture of the Northern Pacific Coast, by Chas. H. Bebb; History and Present Status of the California Missions, by A. B. Benton. Secy., Glenn Brown, The Octagon, Washington, D. C.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

January 13, 29 W. 39th St., New York. Secy., R. W. Pope.

AMERICAN INSTITUTE OF MINING ENGINEERS

February 21, annual business meeting, 29 W. 39th St., New York. Secy., Dr. Joseph Struthers.

AMERICAN SOCIETY OF CIVIL ENGINEERS

January 4, bi-monthly meeting, 220 W. 57th St., New York. Paper: The Valuation of Public Service Corporation Property, Henry Earle Riggs. January 18, 19, annual business meeting; January 20, 21, meetings for topical discussion. Subject; Road Construction and Maintenance. Secy., C. W. Hunt.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

January 24–26, annual meeting, 29 W. 39th St., New York. Secy., W. M. Mackay, Box 1818.

ASSOCIATION OF ONTARIO LAND SURVEYORS

February 28, annual meeting, Parliament Bldgs., Toronto, Can. Secy., Killaly Gamble, 704 Temple Bldg.

AUTOMOBILE EXPOSITION

December 31–January 7, Grand Central Palace, New York. Secy., B. Briscoe, 7 E. 42d St.

BOSTON SOCIETY OF ARCHITECTS

January 3, annual meeting, Parker House, Boston, Mass. Secy., Edwin J. Lewis, Jr., 9 Park St.

CIVIL ENGINEERS SOCIETY OF ST. PAUL

January 9, annual meeting, Old State Capitol Bldg., St. Paul, Minn. Secy., F. D. Jurgensen, 116 Winter St.

ELECTRICAL CONTRACTORS ASSOCIATION OF NEW YORK STATE

January 10, ex-semi annual meeting, Albany, N. Y. Secy., Geo. W. Russell Jr., 25 W. 42d St., New York.

ENGINEERS SOCIETY OF PENNSYLVANIA

January 16, annual meeting, Harrisburg, Pa. Secy., Edw. R. Dasher, Gilbert Bldg.

ENGINEERS SOCIETY OF WESTERN PENNSYLVANIA

January 17, annual meeting, Oliver Bldg., Pittsburg, Pa. Secy., E. K. Hiles, 803 Fulton Bldg.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS

January 25–27, annual meeting, East St. Louis, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Blk., Chicago, Ill.

INDIANA ENGINEERING SOCIETY

January 12–14, annual meeting, Indianapolis, Ind. Secy., Chas. Brossman.

THE NATIONAL CIVIC FEDERATION

January 12–14, annual meeting, Hotel Astor, New York. Chairman Executive Council, Ralph M. Easley, 1 Madison Ave.

NEBRASKA CEMENT USERS ASSOCIATION

February 1–3, annual convention, Omaha. Secy., Peter Palmer, Oakland.

SOCIETY OF AUTOMOBILE ENGINEERS

January 11, 12, annual meeting, New York. Papers: Automobile Springs E. K. Rowland; Highways for Motor Traffic, Logan W. Page; Motor Tests, R. C. Carpenter, Mem.Am.Soc.M.E.; Impurities in Commercial Gasolene, Frank H. Floyd; Gears with Rolled Teeth, A. N. Anderson. General Manager, Coker F. Clarkson.

WISCONSIN ELECTRICAL ASSOCIATION

January, annual meeting, Milwaukee, Wis. Secy., J. S. Allen, Lake Geneva, Wis.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
January			
4	Wireless Institute	S. L. Williams	7.30 p.m.
5	Blue Room Engineering Society	W. D. Sprague	8.15 p.m.
10	American Society Mechanical Engineers	C. W. Rice	8.15 p.m.
12	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
13	American Institute Electrical Engineers	R. W. Pope	8.15 p.m.
17	New York Telephone Society	T. H. Lawrence	8.15 p.m.
20	New York Railroad Club	H. D. Vought	8.15 p.m.
24, 25, 26	American Society of Heating and Ventiating Engineers	W. M. Mackay	All day
25	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.

Date	Society	Secretary	Time
February			
1	Wireless Institute	S. L. Williams	8.00 p.m.
2	Blue Room Engineering Society	W. D. Sprague	8.15 p.m.
9	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
10	American Institute Electrical Engineers	R. W. Pope	8.15 p.m.
14	American Society Mechanical Engineers	C. W. Rice	8.15 p.m.
17	New York Railroad Club	H. D. Vought	8.15 p.m.
21	New York Telephone Society	T. H. Lawrence	8.15 p.m.
22	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.

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1910

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On Advisory Board National Conservation Commission

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On Council of American Association for the Advancement of Science

Alex. C. Humphreys — Fred J. Miller

Note.—Numbers in parentheses indicate number of years the member has yet to serve.

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Institution	Branch Authorized by Council	Honorary Chairman	President	Corresponding Secretary
	1908			
Stevens Inst. of Tech. Hoboken, N. J.	December 4	Alex. C. Humphreys	W. G. H. Brehmer	J. G. Bainbridge
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	1909			
Armour Inst. of Tech. Chicago, Ill.	March 9	G. F. Gebhardt	F. E. Wernick	W. E. Thomas
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Purdue University, Lafayette, Ind.	March 9	L. V. Ludy	H. A. Houston	J. W. Barr
University of Kansas, Lawrence, Kan.	March 9	P. F. Walker	C. E. Johnson	C. A. Swiggett
New York Univ., New York	November 9	C. E. Houghton	Harry Anderson	Andrew Hamilton
Univ. of Illinois, Urbana, Ill.	November 9	W. F. M. Goss	B. L. Keown	C. S. Huntington
Penna. State College, State College, Pa.	November 9	J. P. Jackson	W. E. Heibel	G. M. Forker
Columbia University, New York.	November 9	Chas. E. Lucke	F. T. Lacy	J. L. Haynes
Mass. Inst. of Tech., Boston, Mass.	November 9	Gaetano Lanza	Morrill Mackenzie	Foster Russell
Univ. of Cincinnati, Cincinnati, O.	November 9	J. T. Faig	H. B. Cook	C. J. Malone
Univ. of Wisconsin, Madison, Wis.	November 9	C. C. Thomas	A. MacArthur	A. Wegner
Univ. of Missouri, Columbia, Mo.	December 7	H. Wade Hibbard	H. W. Price	Osmer Edgar
Univ. of Nebraska, Lincoln, Neb.	December 7	C. R. Richards	W. J. Wholenberg	W. H. Burleigh
	1910			
Univ. of Maine, Orono, Me.	February 8	Arthur C. Jewett	A. H. Blaisdell	W. B. Emerson
Univ. of Arkansas, Fayetteville, Ark.	April 12	B. N. Wilson	C. B. Boles	W. Q. Williams
Yale University, New Haven, Conn.	October 11	L. P. Breckenridge	Clayton DuBosque	W. Roy Manny
Rensselaer Poly. Inst., Troy, N. Y.	December 9	A. M. Greene, Jr.	A. M. Greene, Jr.	Harrison Weaver

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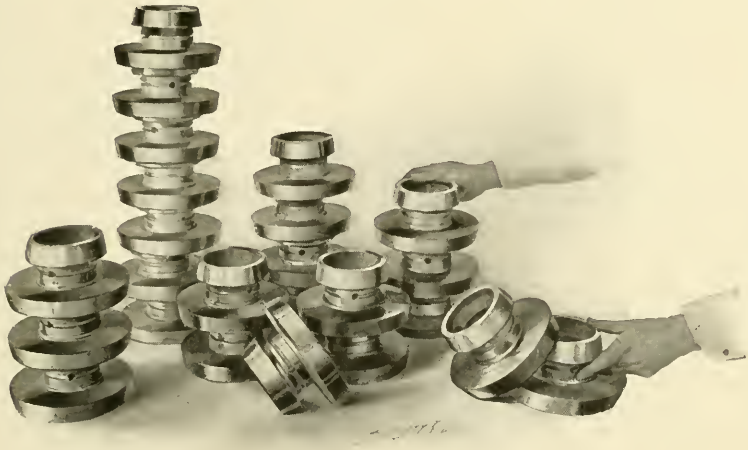

Samples of work for which the machine shown on opposite page is adjusted.

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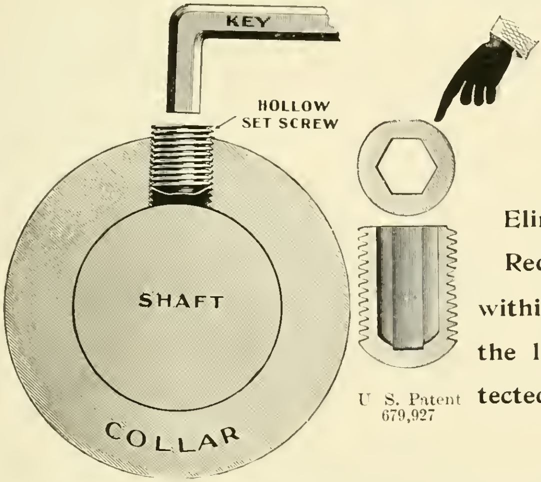

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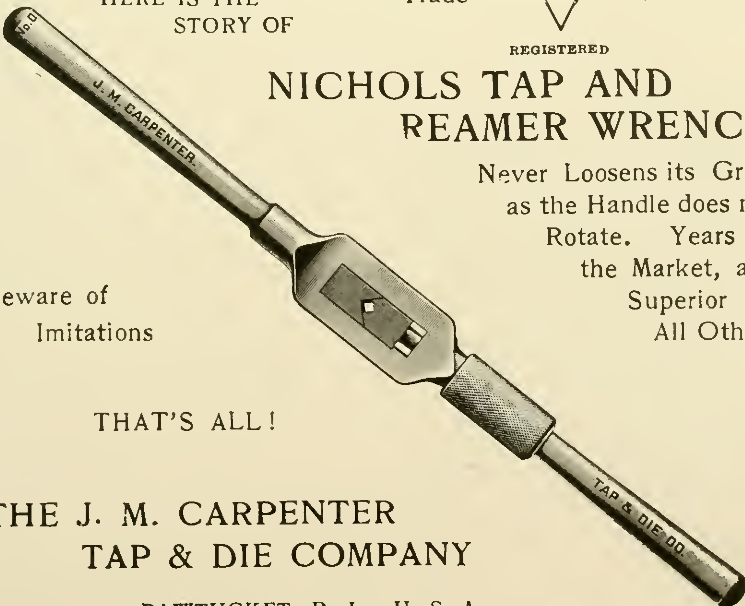

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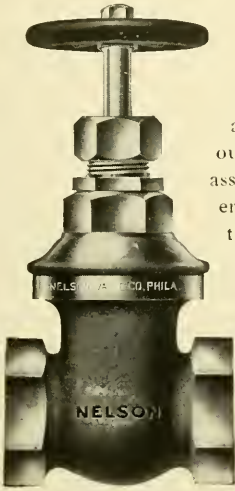

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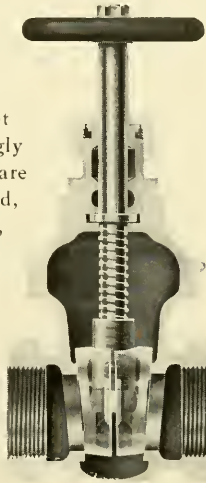
Outside View



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They can be attached in an inverted, horizontal, vertical, angular or any position. Are made for working pressures of 125, 175 and 300 pounds, sizes up to 3″, screwed or flanged.

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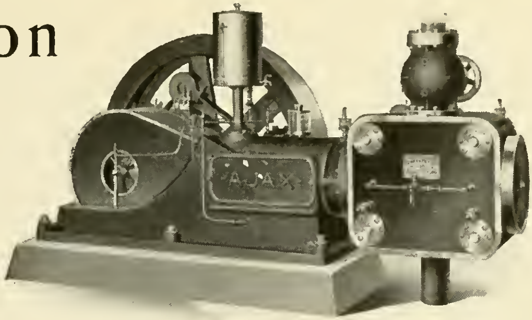

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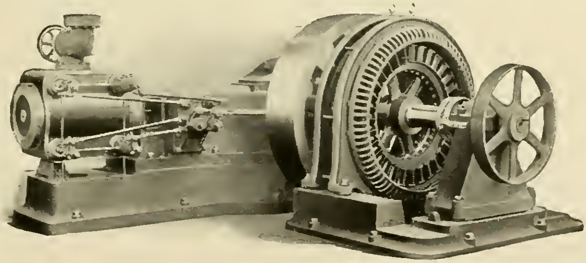

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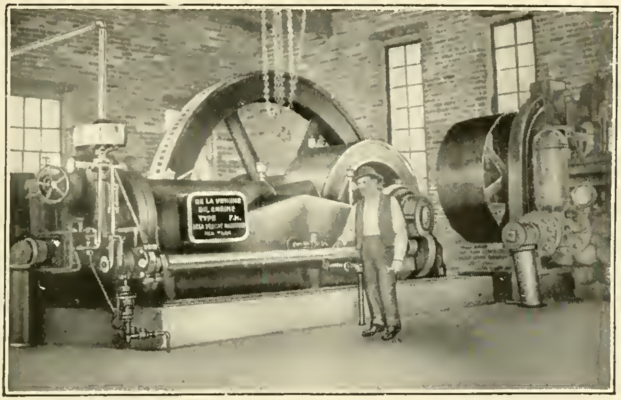

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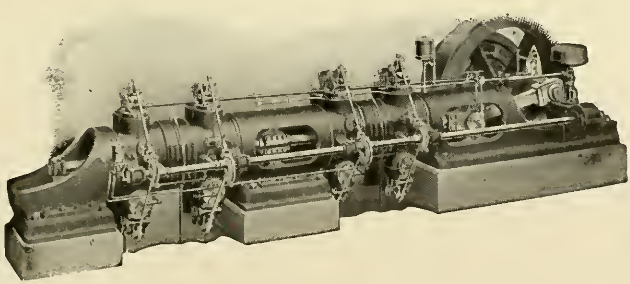

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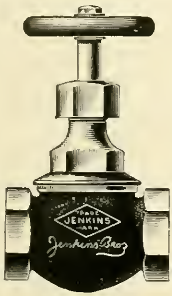

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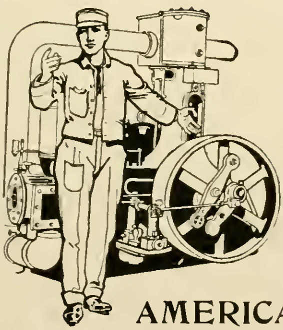

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23

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SECTION 3

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No. 2, 1881	No. 6, 1885	No. 13, 1892, July
No 3, 1882	No. 7, 1886	No. 14, 1893, January
No. 5, 1884	No. 12, 1891, July	No. 14, 1893, July

The American Society of Mechanical Engineers

29 West 39th Street, New York

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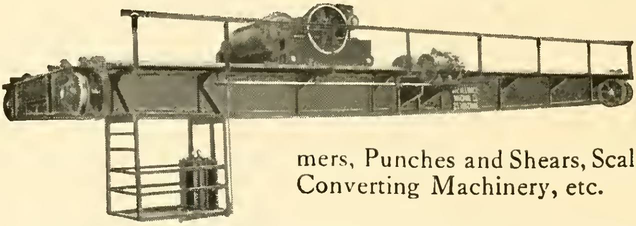

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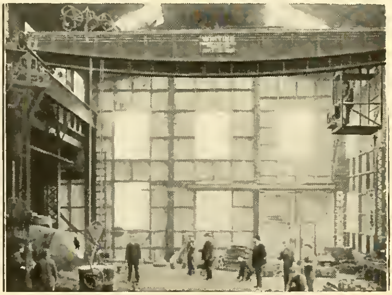

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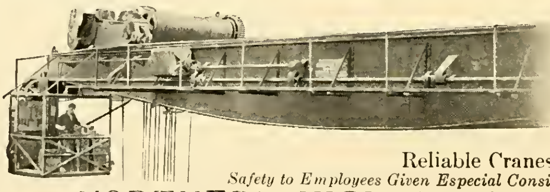

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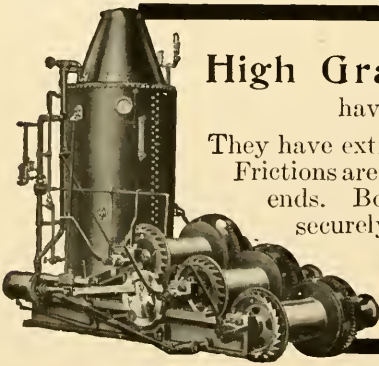

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JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTAINING
THE PROCEEDINGS

FEBRUARY 1911

MEETINGS OF THE SOCIETY: NEW YORK, FEBRUARY 14;
BOSTON, FEBRUARY 17

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VOL. 33 FEBRUARY 1911 NUMBER 2

MEETINGS OF THE SOCIETY

MEETING OF THE SOCIETY IN NEW YORK FEBRUARY 14

At the February meeting of the Society in New York, the subject will be the Mechanical Engineer and the Prevention of Accidents, on which a paper by John Calder of Ilion, N. Y., will be presented by the author. Invitations have been extended to the members of the Industrial Safety Association and the Committee on Industrial Accidents of The National Civic Federation; and arrangements have been made to open to visitors both before and after the meeting the American Museum of Safety, located in the Engineering Societies Building. Discussion is expected from representatives of these organizations and from engineers, manufacturers and others interested in the problem of the prevention of industrial accidents.

MEETING OF THE SOCIETY IN BOSTON, FEBRUARY 17

A meeting of the Boston Section of the American Institute of Electrical Engineers, with the coöperation of The American Society of Mechanical Engineers and the Boston Society of Civil Engineers, will be held on Friday evening, February 17, 1911, in that city. R. A. Philip of the Stone and Webster Engineering Corporation, an associate member of the American Institute of Electrical Engineers, will present a paper on certain phases of the general subject of economic limitations to aggregation of power systems. This paper was suggested by the discussion on Smoke Abatement at the meeting of November, when Dwight T. Randall. Mem.Am.Soc.M.E.

presented it as his view that control of the smoke nuisance could be brought about only by the centralization of coal-burning plants in large units and the elimination of miscellaneous coal burners. The paper by Mr. Philip elaborates this statement.

MEETING OF THE SOCIETY IN NEW YORK, JANUARY 10

At the meeting of the Society in New York, January 10, a paper was read upon the Mechanical Handling of Freight, by Samuel B. Fowler, Consulting Engineer, of Boston, which had previously been presented at a monthly meeting in Boston. The author emphasized the fact that the object in improved terminal facilities is not wholly the reduction in the cost of handling goods, but to a large extent it is to reduce the total transportation cost and to permit a material gain in income from this source and a decrease in rates. The paper was discussed by Lincoln DeGroot Moss, W. B. Waterman, Chas. T. Barney, Spencer Miller, J. H. Norris, S. B. Paine and G. H. Condict. Mr. Condict showed a large number of lantern slides illustrating conditions at terminals in this country and abroad, where there were no mechanical facilities for handling freight, and in contrast to these conditions at certain terminals abroad where modern equipment had been installed.

MEETING OF THE SOCIETY IN PHILADELPHIA, JANUARY 28

A meeting of the members of the Society resident in and near Philadelphia has been called for January 28, 1911, in the Engineers Club of Philadelphia, to discuss the holding of meetings of the Society in that city, on the plan of those already in progress in New York, Boston, St. Louis and San Francisco.

At a preliminary meeting on December 30, at which about thirty of the members were present, a committee, composed of Thos. C. McBride, Chairman, D. R. Yarnall, Secretary, A. C. Jackson, J. E. Gibson, W. C. Kerr, J. C. Parker and James Christie, was chosen to communicate with the Engineers Club of Philadelphia and the Franklin Institute with a view to coöperation.

MEETING OF THE SOCIETY IN BOSTON, JANUARY 31

The January meeting of the Society in Boston with the Boston Section of the American Institute of Electrical Engineers and the Boston Society of Civil Engineers, which will take the form of a dinner

similar to that given a year ago, is announced for January 31 in the Hotel Somerset. Prof. Elihu Thomson, Mem.A.I.E.E., of Lynn., Mass., will be the guest of honor; and official representatives of the three national societies are expected to be present, as well as engineers from New York and elsewhere, many of them representing other societies and scientific or educational institutions. Prof. Arthur E. Kennelly, Mem.A.I.E.E., of Harvard University will act as toastmaster. The dinner last year was attended by over 400 guests and there is every reason to suppose that this event will equal if not surpass the former occasion.

STUDENT BRANCHES

The Armour Institute Student Branch held its regular meeting on January 4, when Charles E. Sargent, Mem.Am.Soc.M.E., read a paper on Gas Engines illustrated by photographs of various engines and engine parts.

At a meeting of the Columbia Student Branch on December 19, A. S. Mann, Mem.Am.Soc.M.E. was the lecturer. He outlined the career of the technical graduate in a large plant, showing that a young man need not be afraid to begin at the bottom, and pointed out the chief cause of failure, the lack of application of knowledge to the solution of practical problems. On January 7, Carlos de Zafra described in a lecture before the Branch the manipulation of large guns, mortars, torpedos and mines. This was illustrated by lantern slides and moving pictures in which the discharging of torpedos and the diving and running of a submarine were shown.

At the November 19 meeting of the Kansas University Student Branch Professor Shaad delivered an address on the Electrification of Steam Railways, which was followed by a general discussion. On December 2, George W. Russell read a paper on Furnaces and Grates; and Prof. Perley F. Walker, Mem.Am.Soc.M.E., presented a paper on Power Plants. At the meeting on December 14, Mr. Phillips gave an address on Induction Motors, which was followed by a general discussion. The second annual meeting was held on January 5, and lasted all day, followed by a dinner in the evening. The professional program included the following papers: Some Recent Improvements in Locomotive Boiler Construction, by William J. Lighty; Results of a Seven-Hour Test on an Air-Lift Pumping Outfit, by John D. Farrell and Thomas A. Purton; An Electric Railway Test, by W. C. McBain, Mem.Am.Soc.M.E., and the Results of a Two-Hour

Test of a 1100-h.p. Gas Engine, by Wilbur H. Judy. Prof. H. Wade Hibbard, Mem.Am.Soc.M.E., delivered an illustrated address on Scientific Management, and Capt. DeF. Chandler, U. S. A., a talk on Aeronautics, amplified by lantern views.

At a meeting of the Stanford University Mechanical Engineering Association on December 14, the following officers were elected for the ensuing semester: H. H. Blee, president, C. H. Benson, vice-president, and E. L. Ford, secretary and treasurer. After the election Prof. W. R. Eckart, Mem.Am.Soc.M.E., gave an illustrated talk on the Modern Irrigation System in Egypt.

The University of Arkansas has held regular meetings on every second and fourth Monday nights since the beginning of the college year. At the meeting on December 19, John Baxendols read a paper on the Design of Heating Plants for Houses relative to the Humidity of the Air, which was followed by a general discussion. Prof. B. R. Wilson, Mem.Am.Soc.M.E., read a paper on Cement and its Uses. This was discussed by Dr. Brough.

At the meeting of the Stevens Engineering Society held on January 6, George P. Ward delivered a paper on the Generation of Steam Power, illustrated by lantern slides. This paper was discussed by Messrs. Blythe, Schroder, Barton and Clouser.

On January 6 the University of Illinois Student Branch held its election. The following are the new officers: F. J. Schlink, president; H. H. Constant, vice-president; E. J. Hasselquist, secretary; and P. A. Faust, treasurer. Following the election, G. W. Philleo discussed the paper by S. L. Napthaly on a Test of a 10,000-kw. Turbine.

MEETING OF THE COUNCIL

A meeting of the Council was held, January 10, 1911, in the rooms of the Society, the President, E. D. Meier, presiding. There were present: Messrs. Brill, Crawford, Herr, Flagg, Gantt, Hartness, Hunt, Hutton, Katte, Moultrop, Reist, Smith, Sando, Vaughan and the Secretary. Regrets were received from Messrs. Humphreys and Goss.

Voted: That the following telegram be sent to Rear-Admiral Melville, Past-President and Honorary Member: Council Mechanical Engineers in session today sends congratulations to its Honorary Member and Past-President on his birthday and wishes him many years of health, activity and usefulness.

The minutes of the meeting of December 9, 1910, were read and approved.

The following deaths were announced: W. L. Pierce, R. B. Talcott, Gus. C. Henning.

The President announced the following appointments: Finance Committee: W. L. Saunders, H. L. Doherty; Library Committee; W. M. McFarland, E. G. Spilsbury; Meetings Committee: C. J. H. Woodbury; Membership Committee: W. H. Boehm; Research Committee; R. C. Carpenter; Publication Committee: Chas. I. Earll; Committee on Resolutions to Institution of Mechanical Engineers: W. F. M. Goss, Chairman, Chas. Whiting Baker and E. D. Meier; House Committee: S. D. Collett; Tellers of Ballot for officers and members: W. T. Donnelly, Geo. A. Orrok, Theodore Stebbins.

The Secretary announced the result of ballot for an Excutive Committee of the Council and that the Committee had met and organized as follows: President E. D. Meier, Chairman, Alex. C. Humphreys, Vice-Chairman, Chas. Whiting Baker, F. R. Hutton, H. L. Gantt, Jesse M. Smith.

Voted: To approve the recommendation of the Executive Committee and to appoint the following Committee on a Code of Ethics: Chas. Wallace Hunt, W. F. M. Goss, John E. Sweet, such Committee to report to Council.

Voted: To approve the application for Student Branch at the State University of Kentucky, Lexington, Ky., and Ohio State University, Columbus, Ohio.

Whereas: A communication has been received from the members of the Society in San Francisco proposing that the Spring Convention of 1915 he held in that city.

Voted: That the invitation be acknowledged with thanks but for reasons of weight decision be deferred.

Voted: To refer to the Executive Committee with power the selection of time and place for the Spring Meeting.

Voted: The following resignations were accepted: C. B. Allen, G. W. Rowel, S. Howard-Smith, St. George H. Cooke, E. Schlemmer, Jr. F. L. Norton, R. B. Hartness, P. C. Morrow, W. S. Morehouse, James M. Cremor, W. D. Forbes, C. W. Boyer, C. J. Julstedt, J. McGeorge, A. S. Vogt, W. O. Webber and E. W. Roberts.

Voted: The following were deemed to have declined election: Chas. R. Ammermann, M. G. Farrell, Wm. H. Hazard, John Orr, Chas. N. Underwood, Evans Ward, L. E. Zatlin, Frank Burgess, T. D. Casserly, H. N. Davock, R. Emerson, Edwin S. Hallett, Wm. H. Lines, B. S. Nelson, D. D. Rowlands, Edson M. Stevens, Jas. L. Wick.

The Secretary read a communication from James M. Dodge, Past-

President, presenting to the Society an autograph letter of James Watt together with an engraving of a picture of Watt by Sir William Beechy, R. A.

Voted: That the Council accept the gift and extend a vote of thanks to Mr. Dodge.

Voted: That the matter of raising the remainder of the share of The American Society of Mechanical Engineers on the mortgage on the property of the Engineering Societies, be referred to a special committee consisting of Chas. Wallace Hunt, Past-President, the Chairman of the Finance Committee, and one other to be selected.

SEVENTIETH BIRTHDAY OF ADMIRAL MELVILLE

On December 31, the attention of a few friends of Rear Admiral Geo. W. Melville, Hon.Mem.Am.Soc.M.E., was called to the fact that

on January 10 he would be seventy years old. The suggestion was made that as many of his friends as possible be notified so that

they could write him letters of congratulation. But upon further consideration even this seemed too modest and simple a method of celebrating this event. The more they thought of it the more the stature of the man and his achievements grew. On January 2 a committee of five was formed who communicated with a hundred

1841 1911

Rear Admiral

George Wallace Melville.

Engineer in Chief U.S. Navy

(Retired)

After a long voyage, replete with adventures and hardships, adverse tempests and uncharted currents, you are now passing the

Seventieth Meridian of Your Life's Journey.

We, your friends unite in wishing you a mellow evening, smooth seas and favoring breezes.

Looking back over the bright wake you have traced on the ocean of life, we see you

First, as a stripling, a leader in torpedo attack or at throttle, or in stoke hole, pushing the ship into action at the close range then necessary.

Next, in your young manhood thrice braving the frozen North in works of rescue:

In your prime, designing and perfecting the machinery which propelled the ships that added Manila and Santiago to the laurels of our navy.

Even now inventing the mechanism which makes possible the rational combination of turbine and screw.

Your Success

the natural result of keen insight, clear reasoning, devotion to duty, undaunted truth and courage which carved pathways through arctic ice and made vibrant with life the very metal of your engines.

Your warm appreciation of the work of colleagues and subordinates, your sinking the man in the work, have endeared you to all who know you, and are an inspiration to every young engineer.

Allow us to present you with a modest but enduring token of our admiration and love for you, on which the engraver's art has indicated a few of the achievements which have made you the model and type of the

American Engineer.

January Tenth Nineteen Eleven

of his friends suggesting the presentation of a substantial memorial. So prompt and warm were the responses that the preparations were at once made and on the morning of January 10, Walter M. McFarland and A. M. Mattice, on behalf of the committee, went to Philadelphia and presented the Admiral with a beautiful silver platter

of admirable workmanship and a memorial resolution handsomely engrossed. These are here reproduced from photographs. In thus honoring a great engineer, the profession did honor to itself.

JAMES WATT LETTER

Through the courtesy of the Crosby Steam Gage and Valve Company who are issuing a James Watt Souvenir, we are enabled to give the wording of the letter written by James Watt and presented to the Society by George Tangye, Esq., at the meeting in Birmingham in July last:

Birmingham, May 10th, 1777.

Dear Sir:

Yours of the 8th before me. Salmons man is making wheel engine boiler and seems to do tolerably well.

I am astonished how Joseph deceived himself and us in his effect of Bow boiler. I have not seen him since—but I remember he told me that there was a prodigious odds in the quality of some of their coals by others. Did you say whether pushing in the damper to a certain degree did not produce a better or as good an effect as opening the hole in chimney—and was you absolutely certain that no feed got into the boiler during time of experiment.

I think that you are in a good train at Shadwell and recollect no more cautions on that head.

I have made the best apology I could to Mrs. B. though she talks the words of wrath; she is in very good humour and all are well.

When I see the table I can reason upon copper boylers.

I saw the Battering Ram, or devil incarnate, go today above 60 strokes per minute and work its own regulators. All the stampers were assembled. They thanked God that Webb could not make feaders in. He told them he had one of these and in hand. Moore wants a score of large ones for his own use. The story is all over Birmingham and I expect we shall have customers by the dozen. I imagine that they may be made to work forges and tilts fast enough for any purpose.

Cleobury Iron has turned out dammed bad, the piston rod for Huel bussey was very well forged by Dixon and upon heating it to float it fell in two at the shooting and Joss rejoiced in his heart thereat, but not Joss nor Joseph could weld it again—nor would it weld to any other iron by no trick.

Dixon is fagotting one out of Sweedish small bars.

The branch of Battering Rams may turn out very cursedly, as I dare say nobody will attempt them with common engines, and I don't know if they could be made to do. I have invented an admirable thing for opening the regulator which acts by a spring and does it quicker than thought. All Webb's fears are that when a larger one goes at the rate that his does, that no body will come near it.

It has demolished all the fixtures many times already, and I suppose must be wholly made of cast iron.

Dangerfield has been here and sett Joss to growling and drinking for two days this week.

I should make myself easy about profits, if any were coming in at all, but a total stagnation as has been hitherto cannot do at all. I am clear that you should make your bargain sure before you leave London and lett us know what we are to gett with some probably, at least.

As to the Cornish affair. It has also struck me that I should go first and that something should be done before you come.

Adieu.

I wish you a clear head and a firm heart on Tuesday. Pray weigh the coals and observe the quality. Keep well with Rothwell. I think he deserves it.

Yours,

J. Watt.

HONORARY MEMBERS OF THE ENGINEERS CLUB

At a meeting of the Engineers Club of New York on January 11, 1911, Rear-Admiral George W. Melville, Hon.Mem.Am.Soc.M.E., and Thomas Alva Edison, Hon.Mem.Am.Soc.M.E., were made honorary members of that organization.

NECROLOGY

GUSTAVUS C. HENNING

Gustavus Charles Henning, one of the foremost experts in the testing of steel and an inventor of testing apparatus, died at his home in New York City on December 30, 1910.

Mr. Henning was born in Brooklyn in 1855, and educated at the Brooklyn Polytechnic Institute. In 1876 he was graduated from Stevens Institute of Technology where during his college course he was fortunate enough to come under the influence of Prof. Robert H. Thurston.

Immediately after graduation he entered upon the work of inspection of steel for engineering structures. This work brought him in touch with the late George S. Morison and made him familiar with the problems of structural material.

His inventive genius and the opportunities for its exercise resulted in the design of a form of extensometer which he described in two papers before the Society, A Mirror Extensometer and A Roller Extensometer. His study of the defects and limitations of the high-powered testing machines operated on the usual hydraulic principle resulted in his design of a testing machine for full size specimens in which the stretch of the adjusting screws is the measure of the stresses upon the test specimen. The two screws, or more, should be fitted with micrometer extensometers and their uniform stretch within the elastic limit of the material would be a constant measure of the effort without the interference from friction inertia and other causes.

Mr. Henning was a great admirer of the Emery design of testing machines and was sent abroad as a representative of the manufacturers for the installation of certain important British and German orders. Acquaintances which he made during this sojourn resulted in his selection as the official delegate and representative of the Society at certain conferences of the International Society for Testing Materials. It was during this time that Mr. Henning made very important contributions to professional literature in the form of partial reports upon Standardization of Methods of Testing, which will be found in the Transactions, Vols. 6, 11, 12, 14, 17, 18 and 20.

The severity of Mr. Henning's labors at this period caused a breakdown of health from which it is fair to say that he never fully recovered.

On the formation of the American Society for Testing Materials, Mr. Henning found himself rather in the insurgent class as the result of his experiences and opinions formed during his professional work. For this reason he took no part in the formation of the standard specifications and attacked them vigorously when presented before the Society. Business changes and the development of special firms with large capacity for the conduct of the work of inspection of structural material resulted in Mr. Henning's abandonment of professional work in that particular field.

The last years of his life during the continuance of a state of health which warranted his attention to business, were devoted to developing the use of the diamond as a cutting face for tools. He found considerable development for this special work in the manufacture of electrical details in hard rubber. He presented a paper before the Society at a monthly meeting in December 1904, elaborating in some detail his special achievements in this field.

Mr. Henning became a member of this Society in 1880. He was also a member of the International Association for Testing Materials, the Iron and Steel Institute of Great Britain, the Iron and Steel Institute of America, the American Society for the Advancement of Science, the American Geographical Society, and the American Institute of Mining Engineers. His other contributions to the Society were Notes on Steel; On the Elastic Curve and Treatment of Structural Steel; and Investigations of Boiler Explosions.

JAMES D. MACPHERSON

James D. Macpherson was born in Glasgow, Scotland, September 15, 1872. He was educated in the public schools of his native city, and there served his apprenticeship in the machine shop. He later went into the drafting room of Lees and Anderson, builders of marine engines, Glasgow.

After a cruise on a tramp steamer, as assistant engineer, he came to the United States in 1891, entering the service of the James Leffell Company, builders of turbines and water wheels, first in New York and later in their shops at Springfield, Ohio. While there he was employed as assistant in the designs for the great turbine plant of the

Niagara Falls Power Company and other work of similar character, until February 1898. He then entered the employ of the Diesel Motor Company of America as chief draftsman and assistant engineer.

By careful reading and home study he had added much theoretical knowledge to his practical experience, and under the guidance of the chief designer, Arthur J. Frith, he mastered the elements of thermodynamics and of electrical science. During 1901 he was active in perfecting and improving the details of construction of the Diesel motor. In 1902 he was chief designer for Diesel engine work for the American and British Manufacturing Company of Providence, R. I.

From August 1903 until his death he was in the employ of the American Diesel Engine Company, first as assistant, and later as chief engineer.

Mr. Macpherson died at Paterson, N. J., on November 9, 1910. He was a man of sterling integrity and loyalty, a careful and conscientious engineer; and the mechanical success of the American type of Diesel engine is in large measure due to him.

He was a member of the Engineers' Club of St. Louis.

WALTER L. PIERCE

Walter L. Pierce was born at Boston, Mass., June 8, 1855, and was educated at the public schools of Boston and New York. In 1878 he entered the employ of the Lidgerwood Manufacturing Company as a stenographer and acquired his technical training while holding this position from private tutors from Stevens Institute. Mr. Pierce was connected with the Lidgerwood Company for thirty-two years, during twenty-nine of which he acted as its secretary and general manager. He died in New York City, December 10, 1910.

Mr. Pierce was remarkable as an organizer and so perfect was his work that no detail of the great business that grew up under his hand was neglected during his long absences from his desk while seeking health. Besides his connection with the Lidgerwood Manufacturing Company he was treasurer of the Hayward Company and of the Gorton-Lidgerwood Company. He was a member of the Engineers' Club, the Machinery Club, of which he was a director, past-president of the National Metal Trades Association, and an associate member of the Naval Architects and Marine Engineers.

EDGAR PARK COLEMAN

Edgar Park Coleman was born July 12, 1867, at Decatur, Ill., and died November 27, 1910, at Buffalo, N. Y. His early education was obtained in the country schools and in the Rose Polytechnic Institute, Terre Haute, Ind. In 1893 he was graduated from Leland Stanford, Jr. University and two years later from Cornell University with the degree of M.M.E. After leaving Cornell he spent one year in the employ of the Metropolitan West Side Elevated Railroad, Chicago, Ill., and the seven years following at the South Chicago Works of the Illinois Steel Company, making quantitative measurements of steam, water, air and gas; efficiency tests of engines, pumps, gas producers, blowers, etc.; and firing boiler trials of hand, stoker, coal dust and gas. He also originated the design now in use of the Porter-Allen 7500-i.h.p. exhaust valve gear; the 8500-i.h.p. extension release gear for Corliss engines and a steam regulating system for five pairs of independent and two cross-compound engines on a common receiver. In 1905 Mr. Coleman took up his work of steam engineering with the Lackawanna Steel Company, Buffalo, N. Y., in which he was engaged at the time of his death.

He was a member of the American Chemical Society and the Park Club of Buffalo.

ROBERT BARNARD TALCOTT

Robert Barnard Talcott was born at Richmond, Va., December 1, 1863, and educated at the public and private schools of that city and of Washington, D. C., later receiving instruction in mechanical drawing in the evening courses of the Linthieum Institute, Georgetown, D. C.

He started his business career by entering the office of W. H. Tenny and Company, merchant millers, Washington, D. C. In 1882 he became draftsman for the E. D. Dent Company, and in 1884 for the supervising architect of the United States Treasury. From October 1906 to February 1909 he was general manager of the Vacuum Cleaner Company of New York City. With the exception of this period, Mr. Talcott, remained in the heating and ventilating division of the supervising architect's office of the United States Treasury until October 1910, when he was furloughed on account of his health. He was at various times assistant chief engineer in this office, consulting mechanical engineer of the Department of Agricul-

ture in Washington and consulting mechanical engineer in connection with the power plant for the United States Soldiers' Home, Washington, and the Walter Reed United States Army Hospital, Washington. He died December 4, 1910, at Lutherville, Md.

Mr. Talcott became a member of this Society in 1907. He was also a member of the American Society of Heating and Ventilating Engineers and the American Society of Inspectors of Plumbing and Sanitary Engineers.

ENERGY AND PRESSURE DROP IN COMPOUND STEAM ENGINES

By Forrest E. Cardullo

ABSTRACT OF PAPER

It is customary to design multi-stage impulse turbines on the assumption that the entropy of the steam remains constant. The effect of fluid friction is to increase the total heat and the entropy of the steam as it flows through the turbine, and to increase unduly the proportion of the power developed in the later stages. An empirical formula is proposed for estimating the quantity of power developed in each stage of such a turbine. This equation is modified so that by its aid the proper pressure drop in each stage may be determined. A graphical solution of the problem is also developed. The methods outlined are applicable to the solution of problems in turbine design when a temperature-entropy table or a total heat-entropy diagram is used.

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ENERGY AND PRESSURE DROP IN COMPOUND STEAM ENGINES

CALCULATIONS OF THE DISTRIBUTION OF ENERGY AND PRESSURE DROP AMONG THE STAGES OF A COMPOUND IMPULSE TURBINE

By Forrest E. Cardullo, Durham, N. H.

Member of the Society

In a paper read before the meeting of the Society of Naval Architects and Marine Engineers in Detroit, June 1909, Prof. C. H. Peabody explains a method of determining the pressure in the steam chests of the several stages of a compound impulse turbine. As a substitute for this method the writer submits the following, suggested largely by the method given in the above mentioned paper, which he believes to be both more simple and more exact in application.

2 The general methods open to the designer for determining the properties of steam during its passage through the turbine are three in number. He may make use of empirical equations giving the relation between the heat content, entropy and temperature or pressure of expanding steam, as was suggested by Dr. Steinmetz.[1] He may make use of Mollier's total heat-entropy diagram which gives the relation between the total heat, entropy, pressure and quality of steam. Or he may make use of a table like that of Professor Peabody giving the relation between the temperature, entropy, total heat, quality and specific volume of steam. The last two methods are both more simple and more accurate than the first one and are to be preferred.

3 Assume that a turbine is to be designed having n stages and that the diameters of the moving elements of each stage are the same.

[1] Proc. Am. Soc. M. E., March 1908.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

Then, in order to have the steam issue from each set of nozzles at the same velocity, it is necessary to have the same heat drop in each stage. The heat drop per stage will, of course, be $\frac{1}{n}$ of the total heat drop. Were there no retransformation of work into heat, it would be necessary only to find from an entropy table or diagram the entropy and total heat of the steam as it enters the turbine, and the total heat, at the same entropy, of steam of the terminal pressure, to subtract the second quantity from the first in order to obtain the total heat drop, and then to divide this drop by the number of stages to obtain the heat drop per stage. The pressures in each stage would then be found by subtracting the heat drop per stage n times from the initial heat content and finding from the table or diagram the pressure of steam having the heat content so found, at the given entropy.

4 This method may be illustrated by the following problem, taken from Professor Peabody's paper: Assume that the initial steam pressure is 164.8 lb. per sq. in. and the final pressure is 1.005 lb. per sq. in., that the steam is initially dry and saturated, and that the number of stages is two. From Professor Peabody's table, we find the initial entropy to be 1.56 and the intial heat content to be 1193.3 B.t.u. The heat content of steam of 1.56 entropy at the terminal pressure is 871.1 B.t.u. The difference between the initial and final heat content, or the heat drop, is 322.2 B.t.u. The heat drop per stage is one-half this or 161.1 B.t.u. The heat content of the steam entering the second stage is 1193.3 − 161.1 = 1032.2 B.t.u. The pressure of steam having this heat content and the entropy 1.56 is 18.4 lb., which would be the absolute pressure of the steam as it enters the steam chest of the second stage.

5 In the actual steam turbine, we find that the quantity of heat transformed into work is only 40 per cent to 70 per cent of the heat theoretically available for transformation by isentropic expansion. A small portion of this is lost by gland leakage, radiation and bearing friction. The most of the missing energy, however, has been retransformed into heat by eddying, fluid friction, blade leakage, etc., and appears in the steam, increasing its entropy. We may assume that in actual practice 60 per cent of the energy theoretically developed in the first stage of this turbine, or 96.0 B.t.u., would be transferred to to the rotating member, and about 40 per cent, or 64.5 B.t.u., would be retransformed into heat, making the heat content of the steam entering the stage, 1193.3 − 96.6 = 1096.7 B.t.u. This would give for

the entropy of the steam at the pressure of 18.4 lb., the value 1.655. The heat content of steam of 1.655 entropy and 1.005 lb. pressure is 925.0 B.t.u., which gives for the heatdrop in the second stage 1096.7 − 925.0 = 171.1 B.t.u. This is more than 6 per cent greater than the heat drop assumed for the first stage. It is plain that in order to equalize the heat drop in the two stages, the pressure range in the first stage must be increased at the expense of that in the second stage. It is also evident, as Professor Peabody has pointed out, that the efficiency of each stage is less than the efficiency of the turbine as a whole, the larger efficiency of the turbine being accounted for by the fact that the steam entering the second and each subsequent stage contains an extra quantity of heat as a result of the inefficiency of the preceding stages, which is available for transformation into work of the succeeding stages.

6 It will be found by trial and adjustment that if the theoretical heat drop per stage, which we may designate by the symbol $\frac{\Delta H}{n}$, be multiplied by the empirical factor $1 + K$, we will have the heat drop per stage which will give an actual equality in the quantity of energy developed in each stage. In the above empirical factor, the value of K is found by the equation

$$K = 0.00056 \left(\frac{n-1}{n}\right) \Delta H \, (1-E)$$

In this equation, n is the number of stages, ΔH is the total heat drop theoretically available by adiabatic expansion between the initial and terminal pressures, and E is the probable thermal efficiency of the turbine. The value of E may be obtained from the equation

$$E = \frac{2545}{S \times \Delta H}$$

In this equation, S is the probable steam consumption per horsepower per hour of the turbine.

7 In the turbine which we are designing, we have assumed the value of this efficiency to be 0.60, the heat drop to be 322.2 B.t.u. and the number of stages to be two.

8 Substituting these values we find

$$K = 0.00056 \left(\frac{2-1}{2}\right) 322.2 \, (1 - 0.60) = 0.036$$

The probable heat drop per stage will therefore be

$$\frac{322.2}{2}(1 + 0.036) = 167.0 \text{ B.t.u.}$$

Allowing this drop in the first stage, we will have for the heat content after the first isentropic expansion 1193.3 − 167.0 = 1026.3 B.t.u. From the entropy table, the pressure of the steam entering the second stage will be 16.86 lb. since this is the pressure corresponding to the entropy 1.56 and the heat-content 1026.3. Since the efficiency of the turbine is 60 per cent, the heat transformed into work is 60 per cent of the theoretical heat drop and the heat transformed into work per stage is

$$\frac{\Delta H}{n} \times E = \frac{322.2}{2} \times 0.60 = 96.7 \text{ B.t.u.}$$

Subtracting this quantity from the initial heat content, we have for the heat content of the steam entering the second stage of the turbine 1193.3 − 96.7 = 1096.6 B.t.u. We therefore have for the entropy of the steam entering the second stage the value 1.663. Assuming the same heat drop in the second stage to be the same as that in the first stage, we will have for the heat content of the steam leaving the second set of nozzles, 1096.6 − 167.0 = 929.6 B.t.u. The pressure of steam having 929.6 B.t.u. heat content at the entropy 1.663 is found to be 1.005 lb. which gives a complete check on our work and shows the calculations to be correct.

9 If it is desired to find only the pressure of the steam as it enters each stage of the turbine, it will be found that we may proceed in the following manner: From the initial heat content of the steam, which we will designate by the symbol H_1, we will subtract the quantity

$$\frac{\Delta H}{n}\left[1 + 0.00056\left(\frac{n-1}{n}\right)\Delta H\,(1 - E)\right] = h_1 \ldots\ldots [1]$$

and write

$$H_1 - h_1 = H_2 \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

From the temperature entropy table determine the pressure of steam of the initial entropy, having for its heat content H_2. This will be the pressure of the steam entering the second stage. Let us now subtract from H_2 the quantity

$$\frac{\Delta H}{n}\left[1 + 0.00056\left(\frac{n-3}{n}\right)\Delta H\,(1 + E)\right] = h_2 \ldots\ldots [3]$$

and obtain

$$H_2 - h_2 = H_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots [4]$$

The heat content, H_3, together with the initial entropy of the steam, will determine the pressure of the steam entering the third stage. The pressure of the steam entering the fourth, fifth, etc., stages is obtained in a similar manner except that we must substitute the quantities $\frac{n-5}{n}$, $\frac{n-7}{n}$, etc., for the quantity $\frac{n-1}{n}$ in [1] to obtain the quantities h_3, h_4, etc. When performing this operation in the case of any particular turbine, it will be found that the value

TABLE 1 METHOD OF DETERMINING PRESSURES

$\Delta H = 322.2$ $\frac{\Delta H}{n} = 53.5$ $0.00056\ \Delta H\ (1-E) = 0.072$

$\frac{n-k}{n}$	$0.072\ \frac{n-k}{n}$	h	H	Pressure
5/6	0.060	56.7	1193.3	164.8
3/6	0.036	55.4	1136.6	81.1
1/6	0.012	54.5	1081.2	37.9
−1/6	−0.012	52.8	1026.7	16.9
−3/6	−0.036	51.6	973.9	7.03
−5/6	−0.060	50.3	922.3	2.81
			872.0	1.00

of h is greater than $\frac{\Delta H}{n}$ for the $\frac{n}{2}$ high-pressure stages, and less than $\frac{\Delta H}{n}$ for the $\frac{n}{2}$ low-pressure stages. So far as the writer is aware, there is no particular reason why this method should give correct results, but experience shows that it does do so.

10 In order to illustrate the method of determinating pressures, we will determine the pressure in each of the stages of a six-stage turbine working between the same limits of pressure as the turbine whose design we have already considered. As before, the initial heat content is 1193.3 and the entropy 1.56. In order to make the application of the method more clear we will arrange the results in tabular form. We will assume that the efficiency, as before, is 0.60. The adiabatic drop will, of course, be 322.2 B.t.u. The work of computation is shown in Table 1.

USE OF MOLLIER'S DIAGRAM

11 The same method may be applied in graphical form to the solution of this class of problems when Mollier's total heat-entropy diagram is used. The writer believes that designers will find the following the best method to use for the graphical solution of this

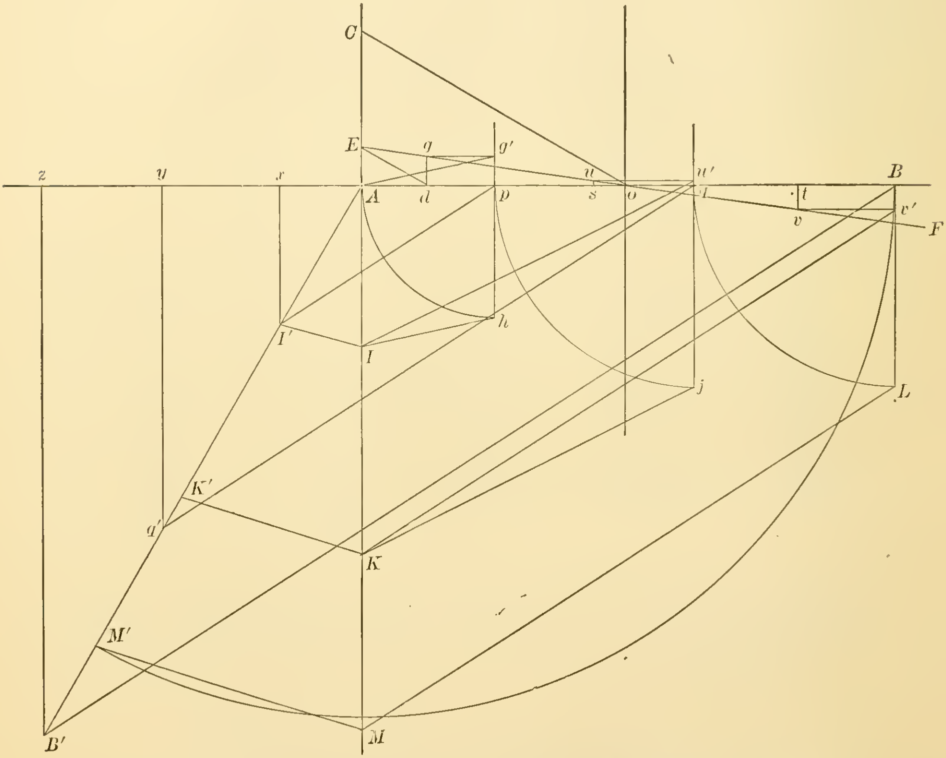

Fig. 1 Graphical Construction Based on Mollier's Diagram

ANGLE C O A IS MUCH LARGER THAN IT SHOULD BE IN ORDER TO MAKE THE CONSTRUCTION CLEAR

problem, when the amounts of power developed by the different stages are unequal, as is sometimes the case. It is assumed that the diagram used is that accompanying Marks' and Davis' steam tables. The diagram, to have real value in the designing office, should be pasted on a well seasoned drawing board and covered with a sheet of very thin celluloid. Knowing the initial pressure and quality, or superheat, of the steam, we find on the diagram the point (*A* in Fig. 2)

representing this state, and through this point on the celluloid covering, draw a constant-heat (horizontal) and a constant-entropy (vertical) line. We will hereafter designate these two lines by the symbols H_1 and N_1 respectively. Find the state point of steam after adiabatic expansion to the exhaust pressure (H_4 in Fig. 2) by finding the intersection of N_1 with the exhaust-pressure line. The distance between the initial and final state points, of course, represents the quantity ΔH on the scale of the heat diagram. On a sheet of good detail paper draw the horizontal line AB as shown in Fig. 1, having a length equal

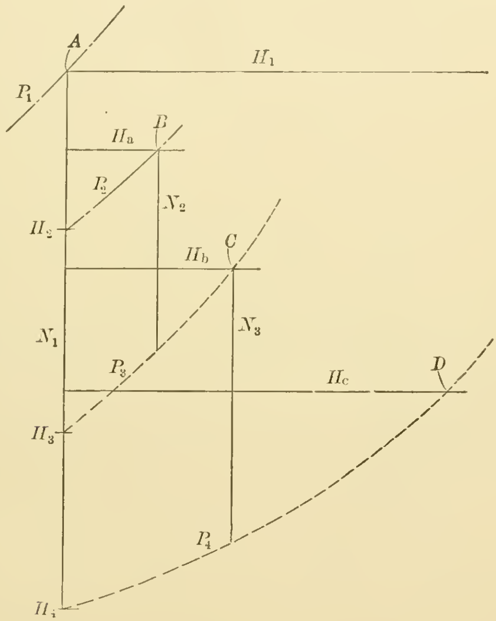

Fig. 2 Showing Use of Mollier's Diagram

to this distance, and bisect it at O. At A, erect a perpendicular, making the length Ac equal to 0.00056 (ΔH^2) $(1-E)$. This may be easily done by setting a protractor at an angle whose tangent is 0.00112 ΔH $(1-E)$ and drawing line Oc through O to intersect Ac at c. Divide AB into the same number of segments as the turbine is to have stages, making the length of each segment proportional to the amount of power which is to be developed in the corresponding stage.

12 Points p and q in Fig. 1 represent the division points between the segments. Bisect each segment to locate the mid-points d, s and

t. Draw de parallel to Oc. Draw ef through O. Erect short perpendiculars at d, s and t, to intersect ef, at g, u and v. Erect perpendiculars through A, p, q and B. Draw horizontals through g, u and v to intersect the perpendiculars through p, q and B, at g', u' and v'. With p as a center, strike arc Ah. In like manner, with q and B as centers, strike arcs pj and ql. Draw Ag', and then hi parallel to it, intersecting the perpendicular through A at i.

13 In the same manner, draw jk and lm parallel respectively to $u'i$ and $v'k$. If the segments into which AB have been divided are all equal, we are now prepared to determine from Mollier's heat diagram the pressures in the steam chests of the several stages in the following manner: Through lines N_1 on the celluloid covering of the heat diagram, draw short lines, H_2, H_3, and H_4 as shown in Fig. 2, making the distances of these several lines from line H_1 equal to Ai, Ak, and Am respectively. The intersections of these lines with line N_1 will determine on the heat diagram, the pressure of the steam in the steam chests of the several stages, or in the exhaust. If the diagram is correctly drawn, Am will be equal in length to AB, and the exhaust pressure found will be that originally fixed upon.

14 If however, the segments are of unequal length for any reason, as would be in the case if the diameters of the several rotating members are unequal, we would find that Am would not be equal to AB, and the exhaust pressure would be incorrect. In order to determine the pressure of the steam entering each stage under these conditions, we must alter our diagram in the following manner: about A as a center, strike an arc in the manner indicated, having the length $A'm'$ equal to AB. Through point A, with a 60-deg. triangle, draw $A'm'$ intersecting the arc at m'. Draw mm', and then draw kk' and li' parallel to it. By following the same procedure as was outlined in the preceding paragraph, but using distances Al', Ak' and Am' to locate H_2, H_3 and H_4, we may readily determine the correct value for the pressure of the steam entering any stage of the turbine.

15 If it is desired to determine from the diagram all of the properties of the steam as it enters each stage of the turbine, and to check the work, we may proceed as follows: Note that Ai' is the actual heat-drop in the first stage, and that the actual heat-drop in each succeeding stage bears the same proportion to its segment as Ai' does to the segment Ap. We may accordingly determine the actual heat drop in each stage by drawing pi', and then drawing qq' and BB' parallel to it, intersecting Am' at q' and B'. We will now have Ai' equal to the actual heat-drop in the first stage, $i'q'$ equal to the actual heat drop

in the second stage and $q'm'$ equal to the actual heat-drop in the third stage. We may complete the design in the following manner: Lay off to the left a distance AZ equal to $E \times AB$ where E is the efficiency of the turbine expressed as a fraction. Draw $B'Z$, and parallel to it $q'Y$ and $i'X$. On the celluloid covering of the diagram draw line H_a parallel to H_1 and at the distance AX below it. Through the point B, determined by the intersection of H_a and the pressure line P_2 determined by H_2, draw line N_2 parallel to N_1. The point B is the state point of the steam entering the second stage. From this point measure downward the distance $i'q'$ on the line N_2. The point so found should fall or the pressure line P_3, determined by H_3. Draw H_b parallel to H_1 and distant Ay from it, and find its intersection at C with the pressure line P_3, determined by H_3. This will be the state point of the steam entering the third stage. Through it draw N_3 parallel to N_1, and from it measure downward on N_3 the distance $q'B'$. The point so obtained should fall on the exhaust-pressure line. Draw H_c distant Ax from H_1 and find its intersection at D with the exhaust-pressure line. This intersection is the state point of the exhaust steam.

16 It is believed that after the designer has once familiarized himself with the method of constructing this diagram, the time required to perform carefully and accurately the directions given and to make all the determinations necessary, will be comparatively short, certainly not more than an hour in the case of a four-stage turbine, and that the method will eliminate much of the tedious labor which is necessary when the method of successive approximation is used in performing this work.

THE MECHANICAL ENGINEER AND PREVENTION OF ACCIDENTS

By John Calder

ABSTRACT OF PAPER

The paper discusses the nature and incidence of industrial injury, its prevalence and high rate, in the United States in particular, and the present general desire for better conditions of safety. It analyzes the chief causes of injury as revealed from a study by the author of a large number of verified casualties and recommends practicable measures calculated to reduce the present numerous fatalities and injuries. It discusses in particular the important services which the mechanical engineer, both as an executive and constructor, can render in exercising his ingenuity to avoid industrial accident.

The paper contains a number of practical safeguarding illustrations from the field of machine building, equipment installation, transmission plant and especially dangerous machines and processes, and concludes with suggestions for administrative and remedial precautions.

CONTENTS

THE MECHANICAL ENGINEER AND PREVENTION OF ACCIDENTS

By John Calder, Ilion, N.Y.

Member of the Society

The conservation of our natural resources has rightly received attention from the Society, but with one exception, the elements hitherto considered have been of a purely material order. The exception is the valuable and timely monograph on The Safeguarding of Life in Theatres which formed the Presidential Address of John R. Freeman at the Annual Meeting of 1905.

2 Yet the preservation, as a national asset, of the lives and limbs of our citizens and industrial workers is more urgent and vital than any steps taken to insure adequate means of subsistence and industry for future generations and an attempt has been made in this paper in a necessarily imperfect way, to treat of the larger field of industrial safeguarding.

3 Accident clauses, wise and less wise, have been included in the labor laws of the various States for some years, but the provision for administering these laws effectively has always been inadequate. Indeed it would seem as if the earlier legislation of this nature, modeled on the latest practice of the older civilizations, was at the time of its enactment considerably in advance of public sentiment. At least, until quite recently, the subject of prevention of accident has signally failed to obtain really serious consideration from employers and employees in general and most safeguarding progress has been due to official compulsion.

4 Legal obligation to safeguard thoroughly has not succeeded in preventing avoidable accidents to any great extent except in the relatively few cases where persuasion and enlightenment have accompanied it. On the other hand, civil liability for the consequences of industrial injuries has been steadily increasing and to the necessarily

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limited efforts of a few State officials, there was added the pressure of insurance underwriters upon employers when accident risks became too onerous. Employers liability is receiving at the present time the careful attention of some of our best legal and business minds, but in this paper it is prevention, not cure or compensation, which is emphasized.

5 The subject of accident prevention, which has by no means been neglected by many careful plant executives, is now coming to the front on that wave of humanitarian consideration which is noticeable everywhere. It is the hope of the writer that mechanical engineers as a professional body will cordially identify themselves with a cause in which they, more than any others, can achieve much good.

6 On its educational and sentimental aspects the public and press of the East have had their interest awakened to some extent by the efforts of the American Museum of Safety Devices, the National Association of Manufacturers, the National Civic Federation and others. On the strictly practical side the broad-based safeguarding work initiated in all its plants at a large outlay by the United States Steel Corporation has received deserved publicity.

7 At the same time the successful operation of thorough preventive measures has been going on unnoticed for years at some relatively few individual works, but these have formed quite a minority among the many plants incurring accident risks which were imperfectly safeguarded. It is the object of the present paper to initiate a discussion of accident prevention by stating in some detail the principles of industrial safeguarding as they have presented themselves to the author and illustrating the art freely by examples drawn chiefly from his experience in plant management.

8 In study and in legislation on this matter we have lagged considerably behind Great Britain, Germany and France, which countries more than thirty years ago began to enforce with strictness and excellent technical judgement, the existing laws for safeguarding industrial workers. In recent visits to mechanical plants in various parts of Europe the author noticed considerable advance over the high standard obtaining there twelve years ago, in protecting the worker from the incidental risks of his employment and from his own ignorance and carelessness.

9 Industrial accident reporting is still very incomplete in the United States and the Federal Government's accident statistics are necessarily below mark; yet Bulletin No. 78 of the Bureau of Labor, September 1908, states that, among adult wage earners alone,

the yearly mortality from accidents is between 30,000 and 35,000. The non-fatal injuries inflicted can not be much less than 2,000,000 additional.

10 These staggering but undoubtedly conservative figures of a single year of peaceful industry far exceed the killed and wounded of several great military campaigns, and when compared with the more thorough foreign accident returns, give us just cause to inquire why we should be so far behind in conserving the lives and health of the industrial worker. The figures take no account of the many casualties affecting women and young people and they are rarely looked into as a whole; but when the truth about them can be recorded it will stir up the most indifferent.

The Mechanical Engineer and Accidents

11 From a comparative study for some years of the conditions of safety under which European and American industries are carried on, the author has come to the conclusion that the progress in this direction so desirable in the interests of the race cannot be attained entirely by acts of legislatures, pressure from State officials, warnings and recommendations from casualty insurance corporations and admonitions from sociologists, valuable though these are.

12 The principles of safeguarding and safeworking in industry should be as much a part of the economic education of the young engineer as those of efficiency and conservation in other directions. The author believes that many engineers enter on responsible control of operations and industries with little or no realization of the employment risks involved. Such a consciousness comes in time, but it is often through the painful and harrowing experience of avoidable accidents and fatalities which were not prevented.

13 The scientific study as a matter of course and the solution by the mechanical engineer of individual problems of safeguarding, supervision and instruction of employees as they arise in their daily routine will do more than all other existing agencies to bring about satisfactory results. The progress of the art of preventing industrial accident, wherever that is practicable, depends very largely upon the amount of intelligent interest manifested in the subject by members of the profession whether engaged in plant maintenance, the manufacture of tools and other apparatus, invention of safeguards or in works administration. In such matters as this the attitude and action of the executive is all-important and gives the keynote to the whole plant.

14 The author wishes to make it clear, however, that all industrial accidents are not considered preventable, either by employer or employee, and that, of those that may be avoided, some do not fall strictly within the engineer's province and a large portion is directly within the control of the injured themselves. Nevertheless, a considerable number of casualties remain which are the most serious in their consequences to operatives and employers alike and which can and ought to be prevented by mechanical and executive precautions and the exercise of the same faculties which the engineer efficiently applies to his other problems.

15 It is believed that, by proper supervision and precautions in all plants and industrial processes and the cultivation of greater care by operatives, at least one-third of the present annual sacrifice of life and limb can be prevented, thus increasing our national assets, and a large amount of human suffering and sorrow obviated. For this belief there are good practical grounds of which one typical instance may be cited.

16 In one plant which had a yearly average of 200 accidents a good deal of consideration was given to preventive measures, both mechanical and administrative. As a result of such steps, which reduced the earning opportunities of no employee, the number of accidents for the last annual period was only 64, with the following analysis after close inquiry into each case:

17 In no instance had any accident occurred in a year's time from negligence of the employer and in only one case was the inquiry contributed to by the negligence of a foreman or responsible overseer. In 25 of the cases the accident was caused solely by the negligence of the person injured and in the remaining 38 cases the occurrence was purely fortuitous, accidental and non-preventable in the most literal sense, no blame being attachable to anyone. The latter evidently represents the unavoidable trade risk of this particular plant. Yet the actual risk, before safeguarding and instruction of employees was seriously undertaken was nearly six times as great and the resultant risk including all cases of carelessness on the part of operatives was less than one-third the original rate. This experience has been repeated in many cases.

The Causes of Accidents

18 In illustrating in the present paper what the mechanical engineer may achieve in this department of the conservation movement

a definition of "accident" and a review of the chief causes of industrial injuries are in order. The word accident in relation to industry is not specifically defined by any statute, but in the legislation of both the old and the new world it has the popular significance of any unforeseen and usually sudden occurrence which results in bodily injury to any person while present at the work-place or even within the boundaries of the employer's premises.

19 The injury, to be reportable as an accident, need not arise out of or in connection with the employee's assigned duties. It is the fact of injury, not the cause, which generally makes an accident reportable under the labor laws to the civil authorities. In some cases a time-limit of absence from work due to accident has been used by statute to eliminate trivial injuries from reports. It is clear, however, that an employee may be lucky enough to escape with very slight bodily injury from a machine or process properly classed as dangerous and that consideration of the safeguarding of the same should not be overlooked because of that fortunate circumstance.

20 For this reason the legislative tendency in all countries now is to call for the reporting of every injury without regard to its extent or the incapacity for work entailed. In this way the official investigator and the work's mechanical engineer are both provided immediately with the necessary data regarding the accident, irrespective of its varying consequences.

21 In analyzing many thousands of industrial accidents, with a view to devising remedies, the author has found the following to be the chief causes: ignorance, carelessness, unsuitable clothing, insufficient lighting, dirty and obstructed workplaces, defects of machinery and structures, and absence of safeguards. In current popular comment on the wastefulness of life and limb in our industrial régime little regard is paid to the facts underlying accident, but well considered action must be based solely on these of which some account follows.

22 Fire, steam generators and other vessels under pressure, electricity, railroads and elevators as contributing factors to accident are omitted from present consideration because they are, of all industrial dangers, those upon which mechanical and other engineers have already lavished attention. It is significant that it is chiefly in cases where property, as well as persons, is liable to injury that preventive measures against accident have as yet been generally and efficiently elaborated.

IGNORANCE

23 In spite of ample facilities now afforded to all for the acquisition of some knowledge of mechanical principles, the author has found some superintendents, a number of foremen, many operatives and not a few managing owners of smaller plants grossly ignorant of the nature of the forces and mechanical arrangement which it is in their power either to control, or to set free with resulting danger to themselves and others.

24 Illustrations of this will occur at once to all works' excutives and it has been to the author a constant matter for regret that organized labor with its unique opportunities has done so little to supplement or complete the mechanical education of its members. Accidents due to the culpable as well as excusable ignorance of supervisors, engineers, millwrights, elevatormen, firemen and guardians of general facilities are frequently very serious and nothing but administrative vigilance in selecting and instructing these employees for their own special risks will suffice to prevent such occurrences.

CARELESSNESS

25 Sometimes combined with ignorance, sometimes sheer thoughtlessness, folly or horseplay, carelessness by operatives stands highest as a cause of industrial accident from the results of which nothing external can do much to shield the worker and those whom he sometimes involves. All plant executives know that many things workmen do and suffer under this head would hardly be credited by the sympathetic outsider with no knowledge of the facts.

26 It is the experience of the author that the bright and nervy American workman, so admirable in many respects, is easily first in taking foolish and wholly unnecessary chances with his life and limbs; chances which in no way add to his efficiency or his earnings. The exaggerated ego manifests itself frequently in ostentatious independence full of danger to himself and to others. The maintenance of strict discipline in the shops, the adoption of salutary punitive measures and the firm elimination of the dangerous employee is all that can be done, in addition to a campaign of education throughout the plant.

UNSUITABLE CLOTHING

27 Accident is caused at many machine parts which are necessarily exposed near the operator and with which he would never come into dangerous contact but for unsuitable or neglected clothing. The ragged sleeve ends, loose ties and open jackets of untidy machinists have again and again been wound upon seemingly trivial parts in motion and through the powerful effect of coil friction have inflicted frightful and often fatal injuries.

28 Not a few survivors have to thank the inferior strength of the usual overall or dust jacket for escape. The large extent to which females are finding agreeable and profitable employment at light repetition machine work calls for special and obvious precautions regarding dress and general tidiness which need not be detailed here.

INSUFFICIENT LIGHTING

29 Insufficient lighting is a cause of numerous accidents, particularly serious and fatal falls. The author has observed that a maximum of accidents occurs towards the close and beginning of each year, that is during November, December and January, the months of minimum daylight. Fig. 1 shows the seasonal distribution for three successive years of about 700 deaths annually from industrial accidents which were reported with other injuries from an area embracing 80,000 plants of varying extents.

30 The influence of the duration and intensity of natural light in working hours on fatal and serious accidents is particularly noticeable in such founding, bridgebuilding, shipbuilding, engineering, and steel and iron works and other operations as have to be carried on within large spaces, often entirely in the open air and not easily illuminated artificially to the exclusion of deep shadows.

31 Within plant buildings the intensity of artificial lighting at the cutting point of tools, for instance, and on very limited machine-tool or bench areas is frequently far above actual requirements and a source of much physical discomfort, while all around the operative a semi-darkness prevails which has a blinding effect in the sudden transitions of the vision required by his employment.

32 It has been found by exact photometric observations of shop-lighting conditions both during the day and at night, that the concentrated illumination by means of shades of ordinary 16-c.p. incandescent units on cutting tools in machines and the area near them

is often several times the intensity of ordinary daylight on the same parts. It is very difficult to convince the operative that he is suffering from too much light at any place and the call is constantly for more light.

33 What is wanted from the safety point of view and also, the author believes, from considerations of power economy, is the elimination by good illuminating engineering of this excessive hard light on

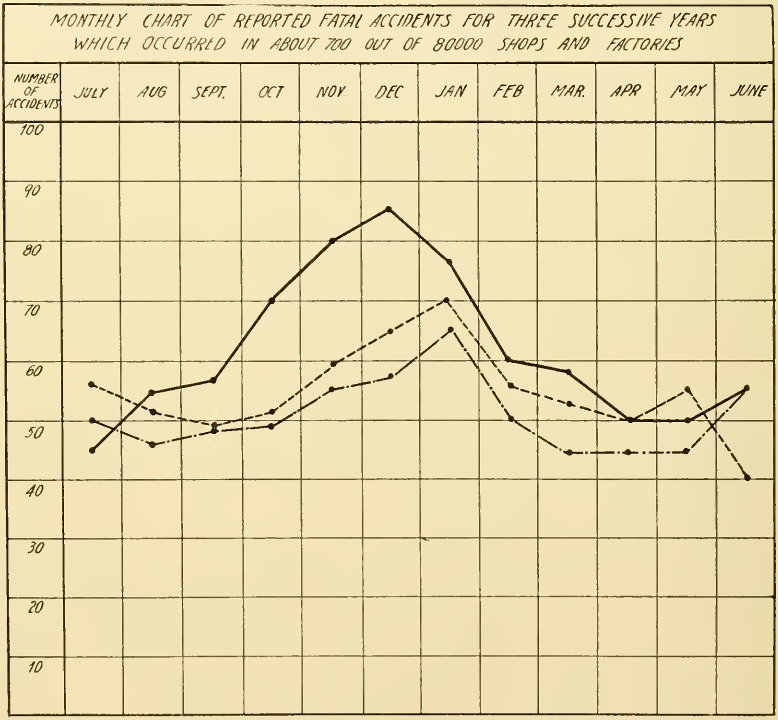


Fig. 1 Influence of Daylight on Accident

spots only, which causes eye-strain and poor vision of surrounding areas with resulting accident. A more generally diffused light of less unit intensity is now easily obtained by the use of fewer but larger screened units experimentally located to suit varying shop requirements and reflecting from whitened wall and ceiling surfaces. The mechanical engineer administering industries or designing plants can do much to reduce the accident risk from this cause.

DIRTY AND OBSTRUCTED WORKPLACES

34 Dirty and obstructed work places are closely allied to defective illumination as a source of accident. The literal "shedding of light" on waste and rubbish is often the sure forerunner of their removal and avoidance of accidents, due to them. Workplaces often retain unnecessarily dirty and obstructed environments causing stumbling and falls and similar accidents, and every management should see to it that the cleaning of floors and passages and the removal of wastes is systematically provided for.

35 Sometimes this condition is due to the habits of the employee himself and he has to be educated to better ways. At other times floor space is economized and machines and workers are crowded together without due regard to safety in moving about in the confined area. Almost all our mechanical operations can be conducted under pleasanter and safer conditions than at present, so far at least as light and cleanliness are concerned. The tidy shop is less costly in the long run than the dirty one and has a noticeable effect on the morale of the whole establishment.

DEFECTS OF MACHINERY AND STRUCTURES

36 A good deal of eloquence has been expended from time to time on the assumed inherent and deadly defects in machinery and structures used in the arts. These indeed contribute to some serious and a number of minor casualties but to nothing like the extent commonly alleged. Altogether apart from the question of specific safeguarding provisions, it has been infrequent in the author's experience to find machines or processes in operation which are essentially dangerous because of defective design or arrangement, or from lack of repairs or renewals, and thereby liable to break down and cause injury.

37 It certainly does not pay any employer to keep a defective tool in operation; nor is it in the interest of the employee, particularly if he is paid by the task, to use imperfect apparatus which reduces his possible earnings. On the other hand, it is by no means infrequent to find workmen, who have their choice of the best materials and apparatus and who possess the intelligence to apply these correctly, showing a striking disregard for their own safety and that of others, especially in framing structures and arrangements of a temporary nature.

38 This is particularly the case in outside work and especially in the building trades, but standardized methods are gradually taking away the workman's initiative in this matter. Workmen persisting in practices of this nature should be eliminated as unfit and dangerous employees and the ability of any untried operative to construct safe facilities to be used by himself and others should never be taken on trust.

39 Overloaded machines and structures, decayed gangways, worn out floors and stair treads, unannealed chains and hooks, frayed and stranded ropes and tackle and a host of minor industrial equipment are items which should pass under systematic and intelligent review from time to time as possible sources of accident.

40 These it may be said are commonplaces, but they are also common neglects both on the part of executives and of workmen themselves. Such attention to safety need be no burden. In the daily routine of plants, whether large or small, if machinery and other equipment is properly selected and installed, and hurry calls for repairs promptly responded to by competent people, and the employees made to feel that suggestions as to real or even imagined defects in the apparatus they must use are welcomed, the team work of good organization will help greatly to eliminate avoidable accidents from these causes, which are usually a reflection upon the executives.

The Possibilities of Safeguarding

ABSENCE OF SAFEGUARDS

41 The absence of safeguards, though not the most prolific cause of accident in plants, closely concerns the mechanical engineer who holds the possibilities largely in his own hands. In the eyes of the public and non-technical investigators it is of first importance. Though our industrial life is characterized by a steady extension of the factory system of production and an increased division of labor using mechanical aids, the accident list need not increase pro rata.

42 In many cases of injuries to operatives caused by the absence of a possible safeguard it will be found that it has been removed, or rendered ineffective by the employee for lack of supervision in such matters or that protection has never been provided. Safeguarding absent at one machine is sometimes actually afforded elsewhere under the same roof and the accident is due to the operation of the principle, that what is permitted to be everybody's or anybody's business is in

daily life nobody's business. The safety engineering of no plant should be left to the haphazard initiative of a number of individuals.

43 Consideration of what the mechanical engineer can contribute to this end naturally falls into two divisions:

- *a* The efficient safeguarding which he may design as an integral part of the machine tools and other apparatus supplied by him for use in the arts.
- *b* The safeguarding which he may later devise and supply as the mechanical engineer or executive of plants using power apparatus and other equipment capable of inflicting injury as installed and which cannot be intelligently protected until all related apparatus is in position and the operating conditions for employees fully apparent.

44 Some degree of finality is necessarily attainable in the simpler forms of safeguards about powerhouses, transmission machinery and dangerous details common to all machines, and most failures to prevent accidents from these are due to lack of consistency and thoroughness in applying the recognized remedies. The safeguarding of some especially dangerous machines and processes is to some extent evolutionary and where it is legally obligatory it must be of the safest type known. So far as statutory compulsion in any one State is concerned the requirement to safeguard the more powerful machine parts is usually absolute. In the much larger field of machine operations in detail, it is conditioned by proof of danger and necessarily by practicability.

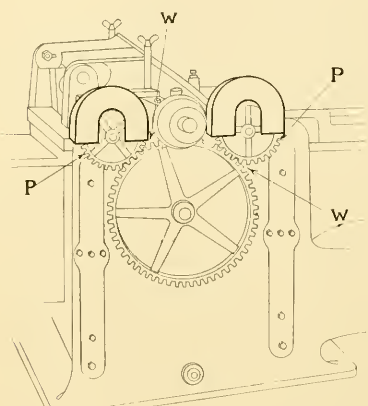
The Machine Builder and Safeguards

45 The machine toolbuilders, many of them members of this Society, have already accomplished a great deal of most useful safeguarding, particularly in protecting the workman from the dangers of toothed gears in metal working and other tools. Now and again, however, a so-called guard is encountered which is simply no guard at all but rather a snare, and which shows conclusively that its designer had appearance rather than utility in mind.

46 Fig. 2 illustrates this, the pinions *PP* being securely covered on the top which is the outrunning and safe side by semi-circular flanged hoods, whereas the intaking and dangerous parts of the gears *WW* are unprotected and have gripped the clothes and limbs of unsuspecting operatives. The covering of the outrunning sides of gears

is often desirable to prevent the lodging of chips and waste in them, but they are usually harmless when exposed. Fig. 3 shows the proper gear protection for the machine illustrated.

47 Numerous instances might be cited of the vague notion expressed in some current machine designs that anything which looks like a cover for a part of a machine necessarily constitutes in daily service an efficient safeguard; sometimes no regard is paid to the actual direc-



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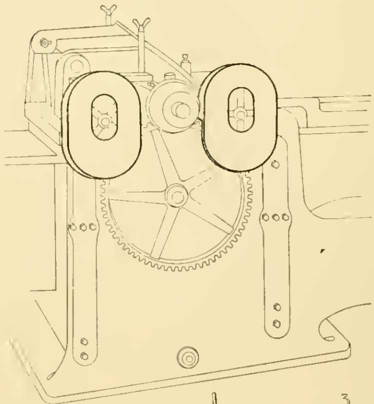

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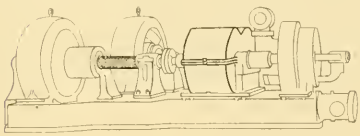

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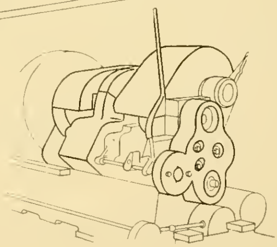

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Fig. 2 Defective Gear Guard
Fig. 3 Safe Gear Guard
Fig. 4 Guarded Steam Turbine
Fig. 5 Lathe Builder's Guard

tion of rotation or to reversal of motion or to the necessity in using the tool for frequently removing a clumsy cover which is as likely as not to be left off permanently. The real points of danger in daily operation need to be studied before a satisfactory protection can be provided.

48 A well designed and neatly applied guard on a machine is seldom a prominent feature and line sketches on which the safeguarding

is emphasized have been prepared by the author for this paper in order to secure the definition of the subject which is usually absent from half-tones made from photographs taken in the shops. Shafts and spindles, low pulleys, and belts, intaking sides of gears, narrow clearances between fixed and moving parts, couplings, projecting screws, nuts and pins and numerous similar risks on moving parts of machines as designed are best handled for protection by the machine builder. In any case the safeguarding of these when within the reach of the operator is usually obligatory upon the employer and always desirable. If absent from machines when delivered the provision of such safeguards naturally falls within the field of the mechanical engineer of the plant.

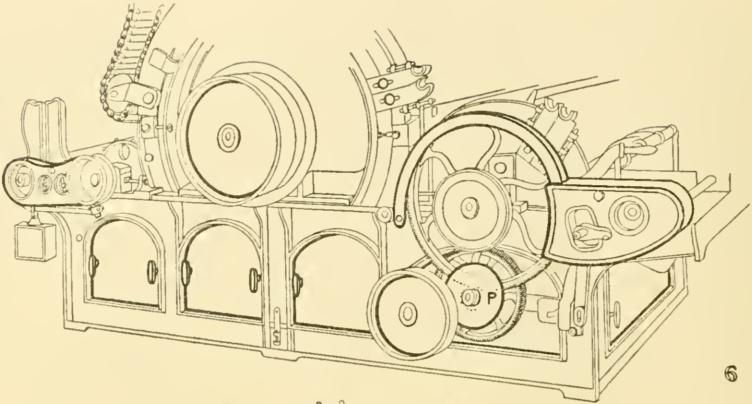
49 Within the scope of this paper the illustrations are necessarily limited to examples of safeguarding from only a few out of the many manufacturing industries concerned, but the principles outlined and the methods shown are applicable with occasional modifications wherever power-driven machinery is operated. Some examples are now given of the effective protection of the machine details just mentioned, a protection which can be and often is provided in greater or lesser degree by the makers of tools and of a large variety of apparatus used in the arts.

50 Fig. 5 is typical of what the tool builders are now doing in the way of neat and effective guards for the toothed gears of lathes and other apparatus, in which access for inspection is easy, and there is no temptation for the workman to throw the guard aside as cumbersome. An illustration of the safeguarding of complicated textile machinery by the makers is shown in Fig. 6.

51 In this machine panels and neat sectional guards of metal are used to minimize the risk of injury at all dangerous parts while in motion. At the same time access for cleaning and inspection at rest can be had in one movement at any protected part. To secure the results indicated careful planning and study of the working conditions are necessary, but where these are given by the mechanical engineer a solution meeting the conflicting conditions of use and safety is nearly always possible.

Guarding of Equipment Built into Position

52 Under the head of guarding of equipment built into position are embraced all power generators and a very large class of machines and industrial apparatus whose accident risks at dangerous parts de-



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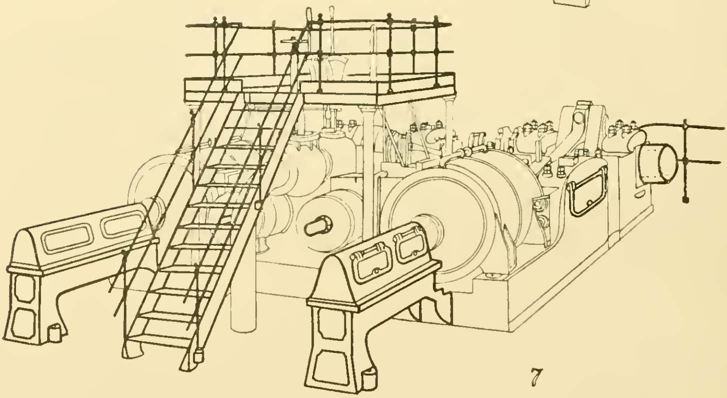

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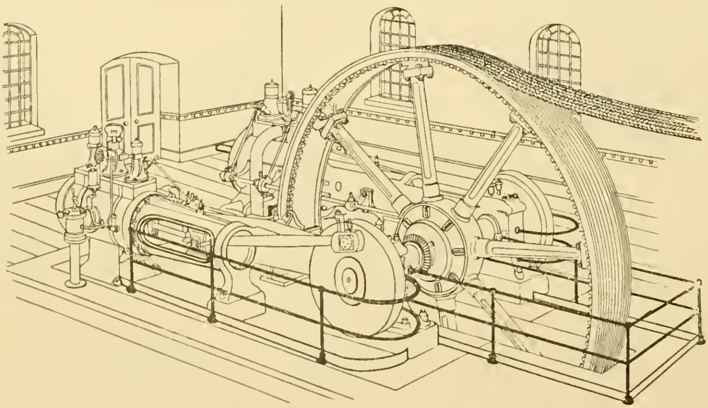

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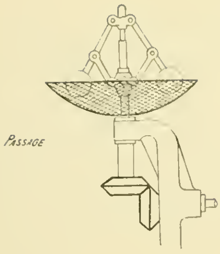
Fig. 6 Guarded Cotton Carder
Fig. 7 Guarded Rolling Mill-Engine
Fig. 8 Guarded Textile Rope-Drive Engine



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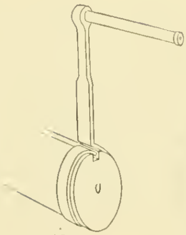
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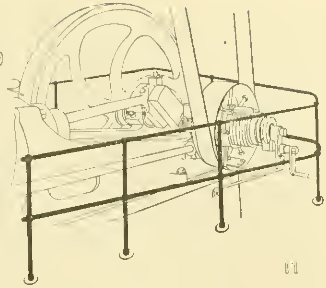
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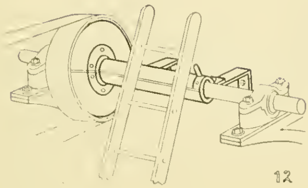
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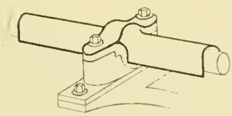

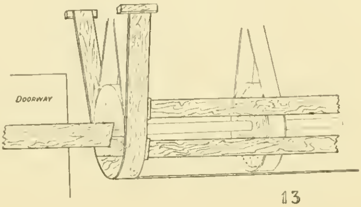

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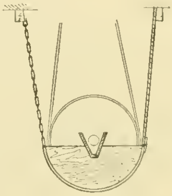
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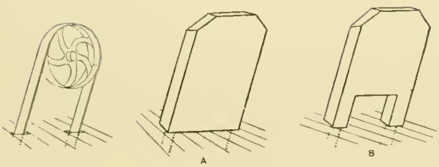

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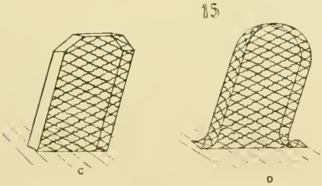

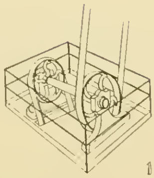
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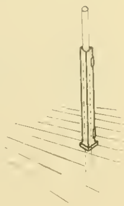
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FIG. 9 GUARDED FLY-BALLS
FIG. 10 GAS ENGINE SAFETY STARTING CRANK
FIG. 11 GUARDED OIL ENGINE AND STARTING CRANK
FIG. 12 TRANSMISSION TUBE AND DISC GUARDS
FIG. 13 PERMANENT LOW OVERHEAD GUARDING
FIG. 14 DETACHABLE LOW OVERHEAD GUARDING
FIG. 15 SCREEN BELT GUARDS
FIG. 16 RAIL BELT GUARDS
FIG. 17 BOX SHAFT GUARD

pend upon the environment, the manner of installation and the precise nature of the workmen's duty around them. Enclosed prime movers such as the steam turbine, Fig. 4, and enclosed high-speed engines, and the extension of electric driving with purchased power, are reducing somewhat the number of small prime mover risks, but there are still in this country numerous reciprocating engines operated by steam, gas and oil and, of considerable age in some cases, which take annual toll of lives and limbs and are inadequately safeguarded.

53 Protection against accident at such apparatus is not secured as is sometimes supposed, by guarding merely the dangerous moving parts. All stationary portions of such prime mover structures as may cause injury to attendants and others should be equally included in the scheme of protection. In power houses the edges of all stairs, platforms, ladders and gratings should have low fenders of metal on both sides which will prevent nuts, bolts, tools and other small parts rolling off into the machinery or striking employees in their fall.

54 In addition a double metal railing not less than 3 ft. high and not nearer any moving part than 12 in. should be provided at all dangerous places such as crank and flywheel pits, etc., and at the inside and outside edges of all stairs and elevated platforms. The fulfilment of these requirements is shown in Fig. 7 on the starting platform, tail-rods and cross-heads of a rolling-mill engine; while the safeguarding of a textile rope-drive engine is shown in Fig. 8.

55 Engine attendants have necessarily to operate often where the footing is slippery and insecure and should be safeguarded when reaching out to bearings close to crank pits and other parts, or in passing around tail-rods and under low fly-balls and other similar parts which can and do cause many serious and not a few fatal injuries particularly on the older prime movers still in service. Figs. 9 shows a protection the author has used on governors and gas and oil engine safeguards are shown in Figs. 10 and 11.

56 The mechanical engineer administering a plant has rarely an opportunity to control and coördinate an equipment entirely modern in character and is often much exercised in safeguarding satisfactorily archaic forms of apparatus in which designers and makers are no longer interested. It is for this reason that some illustrations are shown of forms of protection which are not called for on later and safer designs and installation arrangements.

Guarding of Transmission Machinery

57 The safety of the connecting links between the power house or the shop motors and the individual machine tools and apparatus naturally calls for the mechanical engineer's attention. Transmission machinery, whatever its situation in relation to the floor level, has its accident risk conditioned by the necessity for any workman, having to touch or approach it in motion in the course of his duties.

58 The extensive use of multiplied motor drives, properly screened or at a safe elevation, has done away with many transmission belts, shafts, pulleys, collars and couplings in dangerous proximity to males and females at work in all of our more modern plants. The managers and mechanical engineers of many industries, however, have still to reckon daily with the accident risks of the older type of buildings and transmission arrangements and the latter when not safeguarded are sometimes the cause of horrible fatalities and ought to be closely scrutinized in every detail.

59 Metal tube and disc guards for shafting, bearings and pulleys requiring to be approached closely while in motion are shown in Fig. 12, while forms of protection for transmission in old plants with insufficient headroom are shown in Figs. 13 and 14. Seven feet clear of every moving part is considered the least height from the floor level without guarding and, even then, where a horizontal belt drives across a frequented passage at this minimum elevation it is well to have the lower side screened close to the belt to avoid injuries caused by "whipping" when the belt breaks.

60 Figs. 15, 16 and 17 show guards for belts and shafting driving through floors or at floor levels. Desirable and undesirable forms, respectively, of the shaft couplings, collars and set-screws of transmission apparatus are shown in Fig. 32, while in Fig. 18 are illustrated the safe and unsafe positions for idle belts which sometimes depend from shafts and cause numerous accidents. Fig. 18 also shows the manner in which an unshipped belt, allowed to travel on the shaft, seizes the shaft by its own friction, aided possibly at times by engendered electrification. The slack side *a* by contact with the tight side *b* is carried into the bight *c* and the shaft rolls up the two sides together usually breaking the belt, but in some cases of very light countershafting dislodging the latter and injuring the operatives beneath.

61 The use of the belt perch, Fig. 19, of which there are several forms, prevents the traveling of the belt when unshipped, and accident therefrom; obviates its unnecessary wear and its possible destruction when falling into the narrow gap between a pulley and a bearing. Fig. 21 shows one of several forms of belt replacement pole which does away with any close approach by the machine operator. Special care should be taken by the designers to see that all belt shifting and machine starting and stopping gears are positive in their action. Many accidents have occurred at machines through inefficient or defective fast and loose pulley and belt arrangements suddenly starting a tool which was under examination or adjustment.

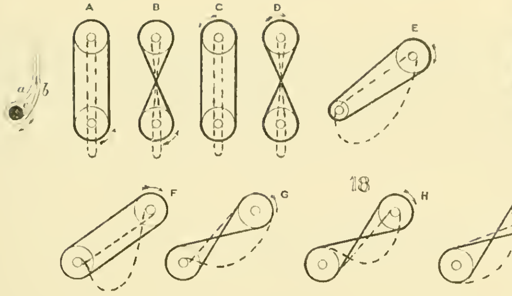
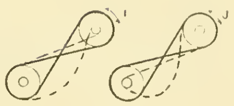
Especially Dangerous Machines

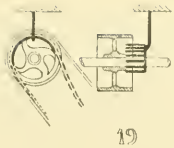
62 The most difficult safeguarding problems for the engineer are those relating to numerous machines used in the arts, which, after the maker and installer have carefully protected all the details already described, are essentially dangerous at the operating point, if worked at all. The variety of uses to which such apparatus is put often precludes the application of a universal guard. Nevertheless protections claiming to be of all-round use are on the market for a number of especially dangerous machines.

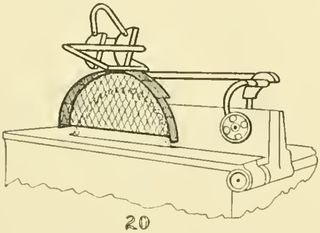
63 No such machine, however, is effectively protected by any guard which hampers a workman, reduces his speed and earnings and has not been designed for the actual working conditions. Such inadequate apparatus is naturally removed by the workman or wholly or partially put out of action at the first opportunity and the particular safeguarding problem becomes the subject of a fruitless triangular controversy between the employer, the employee and the factory inspector.

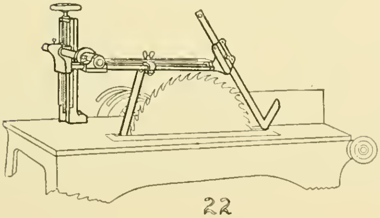
64 To educate the employee to use caution and foresight about dangerous machines is difficult enough and it should not be rendered more so by calling upon him to work with an impracticable safeguard. What is needed in such a case is careful inquiry, by a competent engineer experienced in the study of safeguarding problems, into the conditions under which the employee has to operate and a solution, where such is possible, which will enable him to work with efficiency and safety or at least to reduce considerably the accident risk of his occupation.

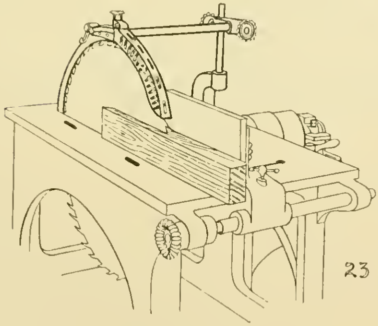
65 For the purpose of illustrating the problem of the especially dangerous machine, the author has confined himself to examples of accident experiences with only four out of many classes of such ap-









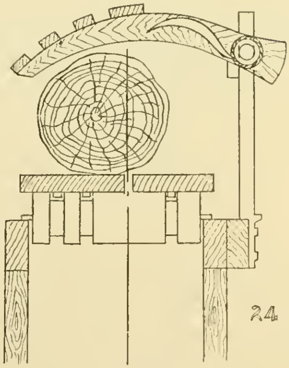


Fig. 18 Safe and Unsafe Idle Belts
Fig. 19 Belt Perch
Fig. 20 Automatic-Positioning Mesh Guard for Variable]Diameter Converting Saw
Fig. 21 Belt Shipping Pole
Fig. 22 Automatic-Positioning Bar Guard for Variable Diameter Converting Saw
Fig. 23 Adjustable Shield Guard for Variable Diameter Converting Saw
Fig. 24 Spar Guard for Log Saw

paratus. These four, however, are probably the most prolific in accident to the operator when performing his usual duties. They comprise woodworking saws and cutters, punches and presses, rolling machinery of all kinds where handfeeding is necessary, and emery and other grinding wheels.

WOODWORKING SAWS

66 A close approach by the fingers of workmen to sharp cutting tools running at a very high rate of speed is essential in operating efficiently many woodworking saws and cutters. Consider first that king of accident producers, the common circular saw, which takes an annual toll of not a few lives. This tool, the author believes, mutilates several thousands of our workmen each year and renders many of these permanently unfit for following dextrous occupations.

67 It is the bête-noir alike of employers, employees, works executives, factory inspectors and casualty insurers. What contribution can the mechanical engineer make towards conservation in this instance? In spite of claims to the contrary such an article as a universal saw guard does not exist on the market. On the other hand, except in the case of small diameter checking and grooving saws covered by the work, the author believes it is quite possible to safeguard all saws to varying degrees conditioned by the uses to which they are put.

68 An efficient as well as a safe saw guard is one which may have to fulfil all or any of the following conditions:

a The safeguarding must be strongly made and once adjusted must be able to retain its position and form without special care on the part of the saw operator.

b It must so protect the saw, both above and below the bench and before and behind the saw that no one can accidently touch or fall upon the saw.

c It must not permit the work in a ripping saw to close upon the blade, mount the same or be projected to the danger of those around.

d It must not obscure the workman's vision of the line of the saw.

e It must be especially adapted to the class of work done on the saw bench and where required, it must leave all the area of the saw table clear of obstruction and also the space above the guard itself.

The ways in which these conditions for reducing saw accidents, while maintaining efficiency, have been met in the author's experience are illustrated in Fig. 20 and in Figs. 22 to 29 for various kinds of saws and applications of such, from the handling of the rough log to completely converted lumber.

69 Fig. 28 shows in some detail the solution of a circular saw-protection problem where the conditions were supposed by workmen and foremen alike to forbid safeguarding which would permit the machines to be worked at full efficiency. The saw-bench illustrated is a combination trimmer and edger having three saws on one shaft.

70 The over-hung saws, a rip and a cross-cut respectively, are fixed in position on the shaft ends but the middle cross-cutting saw must, with any guard, traverse the shaft freely when required for a distance of 18 in. The work handled varies from one to three thicknesses, totalling 2 in. and is fed into the saws on two sliding tables of 29-in. stroke and of fixed and variable gage respectively. Thus no attachment above the bench for any guard is possible at the front or sides or for about the above distance to the rear of the saw.

71 No purchaseable guard will meet such conditions. As finally worked out, the rip-saw has a safety parting-knife fitted in its rear, and all three saws are efficiently and strongly guarded, as shown, at every dangerous point. Men working at a rapid pace on task work at these benches are highly pleased with the result. They are able to use the three saws more effectively than before and without any fear of injury. The saw line is always visible through the mesh work and pierced work, yet the operators hands which necessarily travel with the work can never approach the saw teeth too closely, as they are pushed off by the projecting fingers.

WOODWORKING CUTTERS

72 The common jointer accounts for a large number of finger and hand amputations every year and Figs. 30, 31 and 33 show three forms of effective guard. In the first and third, two movements, vertical and horizontal respectively, are necessary to adapt the guard to any given piece of work. In the second, the guard supported on springs rises automatically when pushed by the work and only the transverse sliding motion is necessary for positioning. After the work has passed the guard the latter returns automatically to a position close to the cutter gap. In the other two types the guards main-

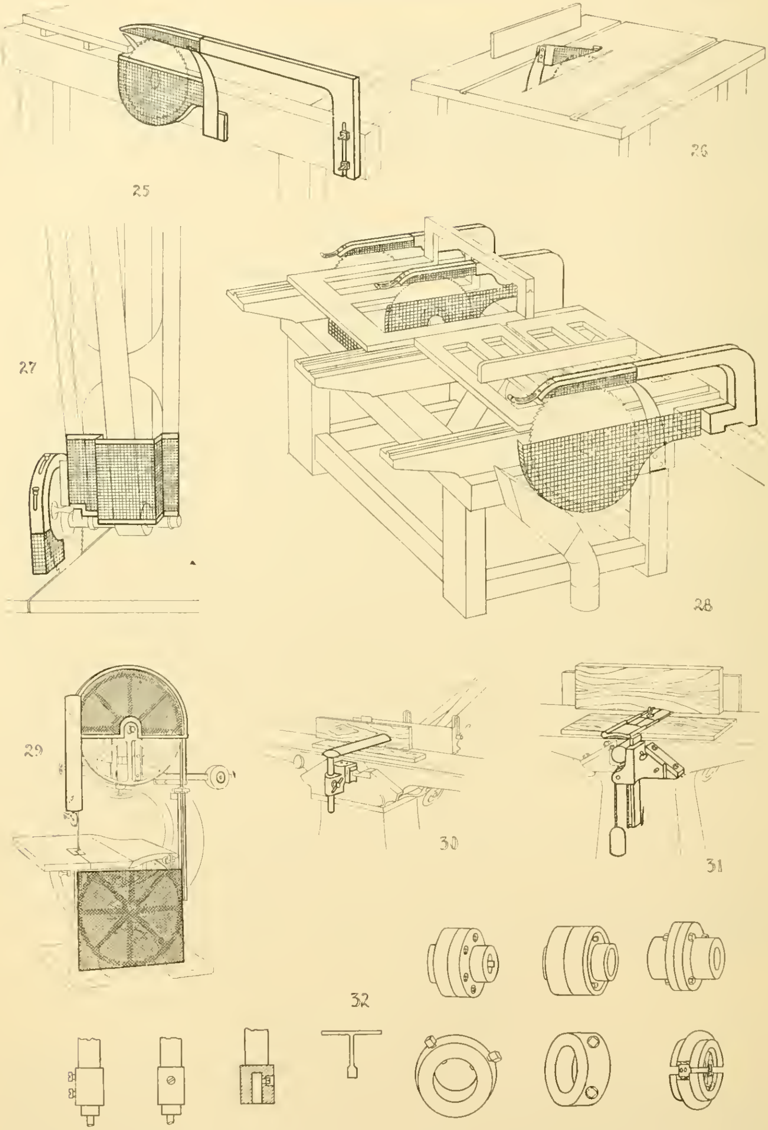


FIG. 25 MESH GUARD FOR CONSTANT DIAMETER OVERHUNG SAW REQUIRING CLEAR BENCH FOR SLIDING TABLE FEED

FIG. 26 MESH GUARD FOR CONSTANT DIAMETER SAW REQUIRING CLEAR BENCH FOR LUMBER

FIG. 27 ADJUSTABLE MESH GUARD FOR SWING SAW AND BELT

FIG. 28 GUARDED TRIPLE-SAW, SLIDE-FEED BENCH WITH CLEAR TABLES

FIG. 29 BAND SAW GUARDED AGAINST CONTACT AT ANY PART AND ALSO AGAINST SAW BREAKAGE

FIG. 30 ADJUSTABLE JOINTER GUARD

FIG. 31 TELESCOPIC JOINTER GUARD

FIG. 32 SAFE AND UNSAFE TRANSMISSION DETAILS: COUPLINGS, COLLARS AND SET SCREWS

tain their height above the table until readjusted. All these guards can be readily swung out of the way for cutter adjustments and as easily returned for use.

73 The vertical spindle molding cutters can also inflict serious injuries. Sometimes a leather knuckle-duster revolves with the tool and contact with it warns the workman of too close approach. Figs. 34, 35 and 36 show three forms of more positive safeguarding for this dangerous tool.

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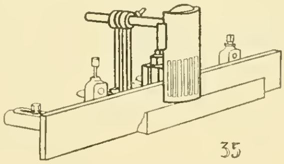

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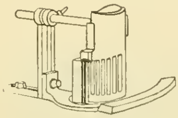

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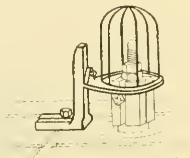

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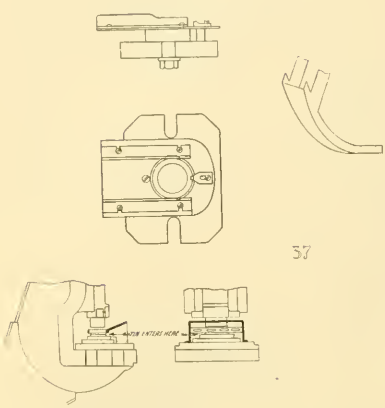
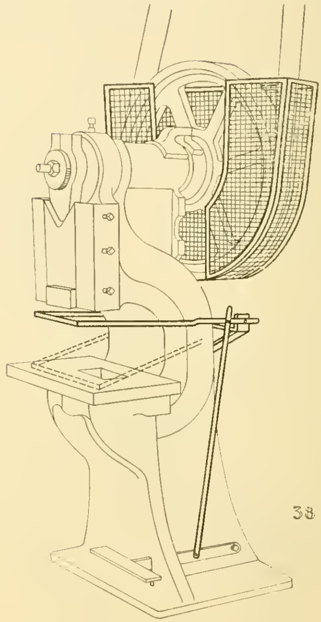
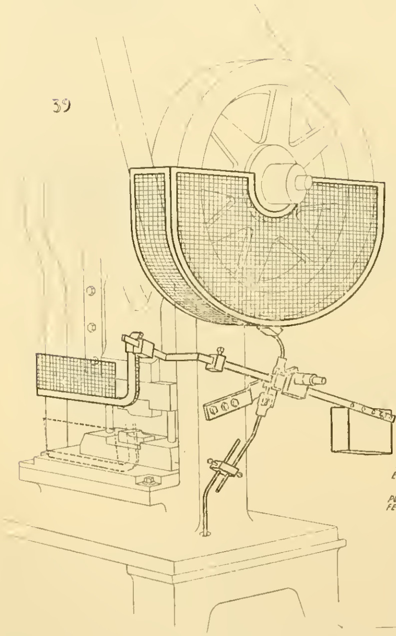
Fig. 33 Automatic-Positioning Jointer Guard
Fig. 34 Spindle Molder Screen Guard, Thin Work
Fig. 35 Spindle Molder Screen Guard, Thick Work
Fig. 36 Spindle Molder Cage Guard

PUNCHES AND PRESSES

74 Punch and press machinery probably ranks next to woodworking tools in frequency of accident, though usually the operative escapes with less serious injury. The mechanical engineer cannot be too careful in seeing that these tools are in good repair, particularly the actuating gears. Automatic roll-feeds, sub-presses, magazine, hopper, gravity slides, Fig. 37, and push slides feeds, Fig. 40, have done a good deal to eliminate the dangers of feeding such pressess by hand but much work already blanked must still be handled in this way in subsequent punching and pressing operations.







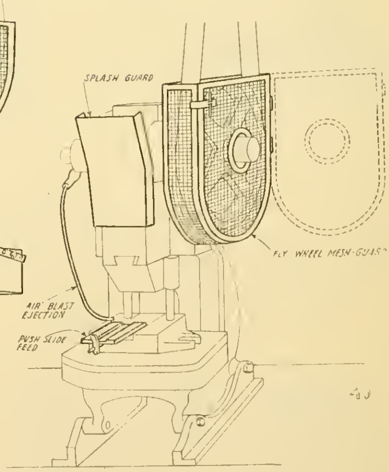


Fig. 37 Gravity Slide Press-Feeds and Screened Punch

Fig. 38 Automatic Bar Guard for Press

Fig. 39 Automatic Screen Guard for Press

Fig. 40 Guarded Flywheel, Splash Guard, Slide Feed and Air-Blast Ejection on Bench Press

75 The increasing use of compressed air in mechanical industries permits of light pieces being blown off the die at the end of the operation by a cam-operated blast properly directed and timed, Fig. 40. The ordinary spring ejector serves the same purpose for heavier work. Yet there are many punches and presses running today without the efficient safeguards here illustrated and even where they are to be found the principles are not carried out consistently at all necessary places.

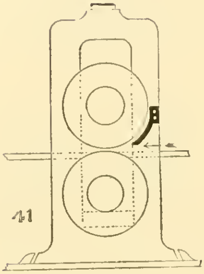
76 Fig. 40 is an example of a convenient flywheel guard, ordinarily locked in position, which the author arranged for a large series of small bench power presses worked by females. Provision is made in it for the tool setter having ready access for moving the flywheel by hand without detachment of the safeguard and resulting failure to replace it. The work in this machine is fed in by a push-slide and removed by a cam-actuated air blast. Figs. 38 and 39 show two forms of press guards, screen and bar respectively, which are timed to descend upon the operators fingers, if in a position of danger, and secure their withdrawal before an accident occurs.

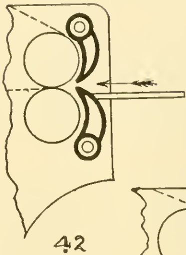
HAND-FED ROLLING AND GLAZING MACHINERY

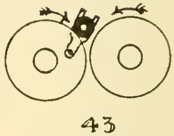
77 The third class of special apparatus essentially dangerous at the operating point is hand-fed rolling machinery of every description. A few of the safety suggestions which can be contributed by the mechanical engineer for this accident risk are illustrated in Figs. 41 to 46. At powerful hand-fed pressing and calendering rolls the injuries are usually very severe.

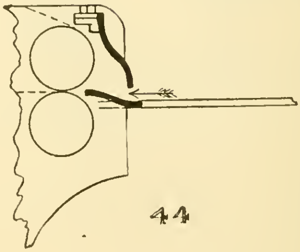
78 In the case of a single pair of large rolls such as are used for paper glazing, Fig. 41, comparatively thin sheets of material are fed in and it is possible by having the feed table level with the top of the lower roll and placing a bar, plate or screen across the bottom of the upper roll, to guard effectively the dangerous intake by arresting the operative's hand when accidentally traveling towards it on the work. Fig. 44 shows this plan applied to rolls used for burnishing sheet metals. In Fig. 42, hinged guards, preferably of mesh work, are used where the intake of the rolls must be at all times visible and instantly accessible. The fixed forms of roll guards, however, wherever possible, are the safest.

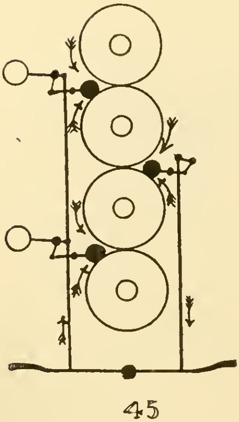
79 It is found in practice that the chance of accident from hand-fed vertical rolls is considerably reduced when a feeding table is used which keeps the operator at a safe minimum distance from the roll intake and











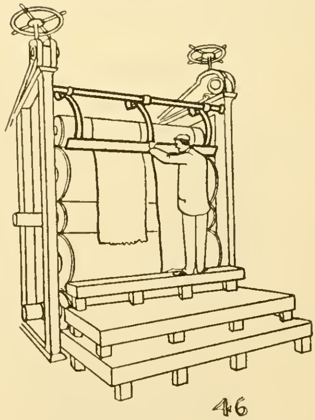


Fig. 41 Guarded Paper-Glazing Rolls
Fig. 42 Hinged Metal Roll Guards
Fig. 43 Laundry Press Safety Roller
Fig. 44 Guarded Metal Burnishing Rolls
Fig. 45 Calendering Machine Safety Rollers
Fig. 46 Calendering Machine "Starting In" Lever

necessitates a conscious effort to reach it. When rolls are operating on plastic materials, for example, in color mixing and baking machinery, easy access for cleaning and scraping the rolls is essential and a suitably placed rod attached to the top roll housing and rising and falling with it takes the place of the plate and mesh guards already illustrated.

80 In laundry and cloth finishing machinery such forms of protection are not practicable on the rolls owing to the nature of the work. To meet such cases a light, smooth auxiliary hardwood roll, Fig. 43, is substituted as a guard. It is pressed constantly against the main rolls by springs and is driven by them, but it fills the dangerous intake and arrests any part of the hand accidentally traveling towards the latter and in danger of being crushed.

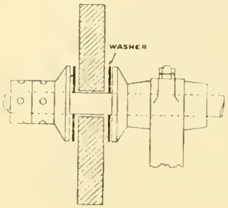
81 In compound power-fed rolls with continuous webs of work such as heavy paper and cloth, calendering machines, multiple floating guard-rolls as above described, Fig. 45, can be used, controlled and released by a system of levers whenever a break in the web necessitates restarting by handfeeding. Fig. 46 shows a method of starting in by hand the feed of a cloth calendering or similar web-pressing machine. A counter-balanced bevel-edged board is used which ordinarily swings up and out of the way. With this the operator can with perfect safety push the cloth or other web home till it is gripped by the rolls.

EMERY AND OTHER GRINDING WHEELS

82 Emery wheels, grindstones and other abrasive tools when overspeeded or when strained or shocked while in motion within the limits prescribed by the makers, sometimes burst with great violence and spread death and serious injury in the path of their flight. Various methods for confining the wheel fragments to the machine casing or at least rendering their velocity harmless have been worked out and some of these are illustrated in Figs. 47 to 51. In all of them ample side clearance between the wheel and its casing is a primary requisite.

83 Fig. 47 shows the method of safely mounting the wheel and avoiding all initial stress due to wedging, keying and driving it into the spindle. Fig. 51 is the cone-sided wheel so shaped that fragments due to a fracture starting at the wheel center cannot escape beyond the washer plates. Figs. 49 and 50 show various forms of armoring successfully used to retain fractured wheels on disc and face grinders.

84 Fig. 48 is especially armored for large wheels subject to shock. It has hinged sides of plate steel and a strong cast-steel front guard also hinged. The guard as a whole can slide parallel to the plane of the wheel to take care of reducing diameter due to wheel wear and the hinged front guard can be dropped to meet the same condition. Wheels have been tested to destruction under all the guards illustrated without projecting fragments. Fig. 52 is a form of releasing



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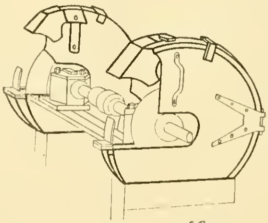

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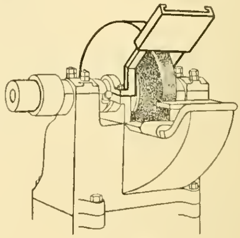

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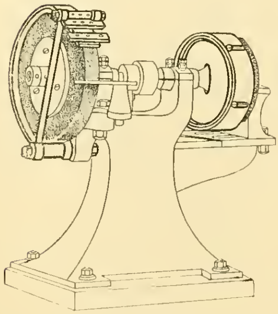

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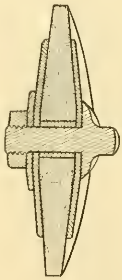

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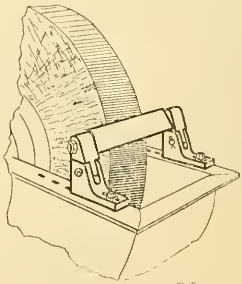

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Fig. 47 Safe Mounting of Grinding Wheel
Fig. 48 Adjustable Heavy Armor for Disc Grinders Subject to Rapid Wear and Shock
Fig. 49 Safety Adjustable Hood for Disc Grinder
Fig. 50 Safety Adjustable Hoods for Disc and Face Grinders
Fig. 51 Safety Cone-Formed Grinding Wheel
Fig. 52 Releasing Grindstone Rest

grindstone rest which prevents accidents due to tools catching between the usual fixed rest and the stone.

Especially Dangerous Processes

85 In addition to the wide scope afforded the mechanical engineer for assisting in the conservation of life and limb in the operation of

industrial machinery, there are not a few matters calling for his attention and for administrative regulation at various dangerous processes used in the arts. Chemical, electrical, metallurgical engineers and other industrial specialists have to reckon with risks to health, which, though not all strictly accidents in the sense we have so far been considering, will probably before long become charges upon industry.

86 Here also our aim as engineers and humane employers of labor should be primarily prevention. In concluding this paper, only passing notice can be taken of the wide field of dangerous processes where the machinery risk is sometimes absent and in safeguarding which the application of the training and experience of the mechanical engineer is essential to the best result.

EMPLOYMENT RISKS

87 In all our industries executives have to reckon closely with the varying degrees of responsibility which can be devolved on the young persons, women and male adults respectively who constitute our labor forces. It would help somewhat in accident prevention, and not a little in educational uplift, if in general hiring practice, no person of either sex under sixteen years of age was employed at or near machinery and if no employee whatsoever was allowed to clean machinery while in motion. The labor laws of the various States are more generous than this in the freedom permitted to employers.

88 Some of the existing restrictions are of doubtful constitutionality; and progress, meanwhile, is more likely to be made through voluntary enlightened action on the part of employers and other executives than by legal compulsion. In any case employment such as described may have serious civil consequences if it results in accident, and any employer is consulting important personal interests when he takes all possible steps to prevent dangerous employment about machinery and processes whether under statutory restriction or not.

RISKS DUE TO POSITION OF MACHINERY

89 The installation of machinery in relation to walls, passages, and adjacent tools and equipment deserves careful consideration from the mechanical engineer. In any confined space over which any person is liable to pass and towards which the carriage of any self-acting or automatic reciprocating machine runs out there should be

left a clear 18-in. passageway between the carriage when fully out and the wall or other fixed structure not part of the machine.

90 Danger due to position also arises in connection with limited clearance between other traveling or reciprocating machine parts and walls or fixed structures, as well as at the openings in the fixed machine framing which they pass. In large lithographic and printing machines the frame openings, often of considerable size, if left unguarded will frequently be used by the employees to store small personal articles. In reaching for these while the heavy table was in motion more than one person has been instantly killed.

91 Readily adjustable sheet metal door or wire screens such as are illustrated in Fig. 6 can easily be adapted to close up such openings, which are used to lighten frame castings, and end clearances of less than 18 in. should be effectively barred off from possible use as passages. Where the speed of the reciprocating part is considerable and a blow rather than a gentle push would be caused by accidental contact with it, the author recommends that the path of the piece be screened off permanently at the extreme end of its maximum working stroke.

STATIONARY EQUIPMENT RISKS

92 The protection by double rails of ordinary open stairs and gangways has already been referred to in discussing the causes of accident and the safeguarding of engines. Perhaps the most serious injuries in connection with fixed structures inside plants occur in chemical and bichromate works and in premises manufacturing paints, colors, oil, paper, soap, starch, sugar, etc., where large open receptacles for stock are in common use and the processes are necessarily continued day and night. These accidents arise from the absence at vats and pans, filled with boiling solutions or with liquors dangerous from their chemical nature, of some form of guard, rail or fence. Around these tanks and on or near their tops, in places often poorly lighted, men have to work. In most cases a double rail, 3 ft. high at least, is easily provided but difficult to keep in good repair, in many instances, in the oxidizing atmosphere of the processes.

93 The author has found the best arrangement to be that where the top 3 ft. of the vat or tank itself is used as a guard or fender and the working platform is this distance below the edge or lip of the dangerous vessel. Where boiling caustic or similar material is contained in the pans the provision of a counterbalanced dome-shaped cover which is ordinarily lowered by tackle over the pan prevents injuries to the

skin and eyes through projection of any dangerous material. Gangways over tanks and vats should be double railed on each side and their efficient maintenance closely watched. It is also well to round off the edges of open tanks or vessels, so that they offer no foot-holds.

94 Great practical difficulties surround the effective protection of workmen on temporary gangways, hatches and stages for the erection of which they are themselves sometimes wholly responsible. Such gang workers on bridge, shipbuilding and other large structural work and at docks will often fail to observe the most elementary precautions and cause many injuries to themselves and to others. Thus a gang of riveters or platers may erect a platform of merely one plank or two, but at intervals in the hull floor spacing a deep frame with plate stays occurs and in passing along rapidly the obstructed headroom is forgotten and a serious and often fatal fall is the result.

GASSING AND BURSTING RISKS

95 Gassing or the accidental inhalation of dangerous vapors is a source of accident in chemical works, gas works, gas storage plants, breweries, distilleries, etc., with fatal consequences sometimes where speedy rescue is lacking. Special means for efficient mechanical ventilation of such processes have to be devised by the engineer as well as close supervision and instruction of the semi-skilled labor found in such plants. The gassing risk, however, is not confined to such works. The upsetting, or accidental fracture of a carboy of acid in the pickling, plating or other room or store of any mechanical industry calls for quick and intelligent action.

96 One instance only will be cited of the striking ignorance still to be found among men long engaged in dangerous processes. A bricklayer who had been employed for fifteen years in a chemical works was called to repair a damaged stone-slab hydro-chloric acid tank in the open yard. On removing the earthenware cock some residual acid ran out on the ground and, without the least consciousness of danger, the workman threw a shovelful of plant wastes containing sulphides on the acid to absorb it and stepped upon the platform to repair the stone tank. Immediately deadly sulphuretted hydrogen was evolved below him from the mixture and gradually rose to the bricklayer's breathing level causing instant collapse and death. So little do operatives know or care to know about what is going on daily around

them that care should be taken to instruct them in elementary safety precautions and correct remedial treatment.

97 The ordinary explosion risks are well known and generally provided for in steam generators and other closed vessels under regulated pressure. In chemical and similar works, in the manufacture of dinitro-benzole and other explosives and in cartridge and shell filling the special risks call for the attention of the engineer, particularly in effective gas and dust removal and need not be detailed here. One class of explosive accident which is rarely fatal, but usually quite severe in its effects, particularly on the eyes, is the bursting of bottles in glass works under compressed air tests, and the explosion of bottles when being filled in plants with various aerated liquids. The painful lacerations and injuries caused in this way from projected glass fragments can be largely avoided by screening adjoining testing and bottling machines from each other and providing light wire-net masks, face-guards and veils and gauntlets for the arms and fingers of workmen handling bottles liable to burst.

Conclusion

98 In concluding this review of the field of industrial safeguarding in its more important manufacturing aspects and with special reference to its close relations to the art of the mechanical engineer, some administrative precautions should be briefly noticed.

DURABILITY AND IDENTIFICATION OF SAFEGUARDS

Safeguards, where at all possible, should be constructed of metal to secure durability. Reinforced steel mesh work is preferred by the author for all but the heaviest machinery. It is superior to guards of opaque material since it permits easy inspection without detaching the safeguard and interferes as little as possible with lighting conditions. In steel mills, foundries and heavy work plants of various descriptions, where the wear and tear of equipment is very great nothing but strong castings or steel plate work should be used for the majority of the guards. It is the practice of the author to have all safeguards readily distinguished by painting the body of them vermillion and the reinforced edges black. This allows executives to detect at a glance in going through the shops a displaced or defective guard, such parts being often small in area, in inconspicuous places, and liable to be overlooked.

WARNING AND CAUTION NOTICES

99 These should be sparingly used and as brief as possible. They give a possible legal protection from certain kinds of accident damage suits but they are practically worthless in every sense if no attempt is made to enforce them. The supervisory and educational efforts of fully instructed and sympathetic foremen receiving full credit for the safeworking of their respective departments and a few well-considered and enforced regulations prominently displayed in print are, the author believes, far more effective than a long catalogue of works rules which few will read and none will remember.

FIRST AID

100 It has been the practice of the author to give immediate and competent first-aid services within the plant to every injured person. The prompt cleaning and dressing of slight accidental wounds gives great relief to the sufferer and renders any later medical attention more effective. In the majority of cases nothing more is needed but neglected or delayed treatment of simple injuries may have most serious consequences.

ACCIDENT REGISTERS

101 Every works executive and engineer will find it a valuable adjunct to the safety engineering of the plant to maintain in every department, apart from labor law and casualty insurance reports, a full and accurate record of every accident and also of every near accident. Periodical examination of these and the determination of every mechanical engineer to practice safety engineering to the best of his ability, without regard to the legal minimum or compulsion, will help more than anything else to remove speedily a great reproach from our industrial life.

SPEED REGULATION IN HYDRO-ELECTRIC PLANTS

By Wm. F. Uhl

ABSTRACT OF PAPER

To obtain satisfactory speed regulation in a hydro-electric plant, it is usually insufficient to provide the turbine units with well designed governors.

Where the turbines are of the open flume type, and the velocity of approach does not exceed three to four feet per second, satisfactory regulation depends upon the fly-wheel effect of the rotating masses only, and the formula for calculating the speed variation is

$$d = \frac{800{,}000 \times \text{h.p.} \times \text{time}}{\text{r.p.m.} \times \text{r.p.m.} \times Wr^2}$$

Where encased turbines are employed, pressure variations occur which modify the results obtained from this formula. The ratio of the length of the turbine penstock to the head $\left(\frac{L}{H}\right)$, is a measure of the effect of these pressure variations. When this ratio is too great to obtain satisfactory results, the design of parts of the plant must be modified, or appurtenances such as pressure regulators and standpipes must be employed to reduce the pressure variations.

Tables are attached which give the pressure variations for various governor regulating times when the ratio $\left(\frac{L}{H}\right)$ and the penstock velocity are known.

SPEED REGULATION IN HYDRO-ELECTRIC PLANTS

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Non-Member

Although speed regulation of the turbine unit is one of the most important features in a successfully operating hydro-electric plant under modern conditions, it rarely receives more consideration in the design of a plant than to provide for the installation of a governor of some standard type.

2 The result is that a hydraulic turbine governor may be praised in one plant and condemned in another almost exactly similar, and the engineer contemplating such an installation often finds after the most thorough investigation that he can obtain recommendations and condemnations of every governor on the market.

3 The reason for this is invariably evident from an analysis of the various features of the plants regarding which information may be at hand, and of the original purpose for which any particular governor was designed.

4 Many plants where speed regulation has never received consideration operate under ideal conditions while other plants in which the conditions are not so good or are perhaps bad, have loads which are almost constant, and therefore practically no regulation is required. In these the most severe tests to which the governor is put, is to shut down the turbine in case of a short circuit and it is not surprising that good reports of governor operation are obtainable from engineers in charge of them. On the other hand, it often happens that governors are installed where the conditions for speed regulation are severe, or where the instantaneous or constant load changes are a large percent of the unit or plant capacity, and if the subject was not given proper

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consideration in the design of the plant, it is not surprising that bad reports are given of the same governors, which in the other plants are highly satisfactory.

5 In the present state of governor development, there is no reason why commercial regulation should not be obtained in every hydro-electric plant and even if not always equal to that obtained in modern steam plants, should at least be very nearly as satisfactory. This, however, can not always be accomplished by the installation of a well-designed governor alone, as the governor can perform only certain of the many functions which it is necessary to execute, no matter how perfect it is. In other words, it is necessary that the several parts of the whole hydro-electric plant be put in such relation that the governor, if properly designed, can perform the functions necessary for good commercial regulation.

6 If the plant has been arranged as above stated, very little difficulty will be experienced with any one of the governors put on the market by a number of reputable manufacturers in this country. There are cases, however, where the governor of one particular type or design may be more adaptable than the rest or some of the rest.

7 The sale of a governor is seldom left to the designer, who may know its limits and possibilities, and it is therefore important that the guarantee made by the manufacturer or his agent be carefully checked by the engineer designing the plant in which the governor is to be installed, even though the governor be the best on the market.

8 Some well-designed governors are in bad repute with some engineers, simply because the manufacturer or his agents were so eager to make a sale, that the question of adaptability, or the conditions under which the governor was to operate were overlooked, or if considered at all, the chance was gambled on that the plant would be an easy one to operate.

9 It is the purpose of this paper to give formulae by means of which the probable speed regulation can be computed for any set of conditions, and to make suggestions which may be helpful in arriving at a satisfactory proportioning of parts for good commercial results.

10 The regulation of hydro-electric units as now accomplished is one of degree only, since a departure from normal speed is necessary before the governor can act. Since the immediate effect of the gate motion is opposite to that intended, the speed will depart still further from the normal. This tends to cause the governor to move the gate too far, with the result that the speed will not only return to normal as soon as the inertia of the water and the rotating parts is

overcome, but may rush far beyond normal in the opposite direction. The obvious tendency is thus to cause the speed to oscillate above and below normal (hunting or racing) to the almost complete destruction of speed regulation.

11 A successful governor must therefore anticipate the effect of any gate movement. It must move the gate to, or only slightly beyond, the position which will give normal speed when readjustment to uniform flow in the flume or penstock has taken place. A governor with this property or quality is commonly said to be a "dead-beat" governor. The expedient used for this purpose on hydraulic governors is called a compensating device, which may be either simple or compound.

REGULATION OF OPEN-FLUME TURBINES

12 For the regulation of turbines in open flumes, where the velocity of approach does not exceed 2 to 3 ft. per sec., a gate movement only slightly increases or decreases the head, so that it may be considered that the immediate effect is the desired one, namely, to increase the flow of water for gate opening and decrease it for gate closing, so that the inertia of the water may be disregarded, consideration for the inertia of the rotating masses only being necessary. Thus in plants where turbines are used in open flume the danger of hunting or racing is practically eliminated, and by choosing the proper value for the rotating masses almost any desired speed regulation can be obtained. However, this is true only where the length of the draft tube is short compared with the head. The water in the draft tube must be accelerated or retarded at each change of gate opening and its kinetic energy changed at the expense of the power output in exactly the same manner as that in the penstock or flume. The effect is a tendency towards hunting or racing and it may be found that regulation with a governor is absolutely impossible at part load. In any case where a draft tube is used it must be included in all calculations. If the draft tube is long, and the velocity in it comparatively high, a quick closure of the turbine gates may cause the water in the draft tube to run away from the wheel, actually creating a vacuum, and then return again causing a destructive blow against the turbine. In such case, regulation of any kind is entirely out of the question.

13 From what has just been said, it is evident that with turbines in open flume, if there is a suitable velocity of approach in the flume and the draft tube is of proper dimensions, the regulation is a question of the inertia of the rotating masses of flywheel effect.

FLYWHEEL EFFECT

14 Flywheel effect is the capacity of a rotating mass to store or supply energy. This effect is expressed in pounds at 1-ft. radius, and is equal to the moment of inertia of a mass, that is, the weight by the square of the radius of gyration, or pounds feet squared. Modern alternating-current generator rotors are built in the shape of a common flywheel and usually have sufficient flywheel effect to obtain satisfactory regulation. The flywheel effect of the rotating parts of a turbine varies with different types and usually is not considered; but it should be carefully considered for large low-head multiplex and large diameter impulse turbines. In smaller turbines it may be regarded simply as introducing a factor of safety.

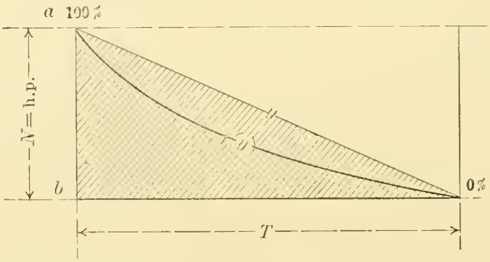


Fig. 1 Energy of Rotating Masses given Out in Time T

15 In turbines of very large diameter and in high-power reaction turbines, the weight of the water in the runner must also be considered to make the calculations of any value as its effect is exactly the same as that of any other rotating mass, and may be a large percentage of the total rotating mass. With geared turbines, the effect of all gears and shafting should be considered.

16 Where turbine-driven direct current exciters are used in a large hydro-electric plant, their possible regulation should be carefully considered, as the flywheel effect of these exciter generators is usually small and an additional separate flywheel may prove necessary.

17 When purchasing generators, a comparison of the flywheel effect should be made, as they are usually built as light and compact as possible. Additional flywheel effect within certain limits can usually be obtained at a very small cost in alternating-current generator rotors, and it will usually prove cheaper and more convenient to do this than to add a separate flywheel.

18 If a separate flywheel must be added, its weight for a given moment of inertia or flywheel effect depends upon the permissible

peripheral speed. In calculating a flywheel, the runaway speed (for full gate opening and friction load) must be considered and is really the determining factor. For an impulse turbine this runaway speed will be about 90 per cent above normal. For the standard types of reaction runners, A, B, C, D, E, and F (Table 1), the runaway speed will be respectively 70%, 65%, 60%, 55%, 50% and 45% above normal. These are the maximum speeds and they may be appreciably less, depending upon the setting of the turbine and the type of bearings used. For low speeds, flywheels of the engine type may be used, but for high speeds they should be of the disc type, turned all over and carefully balanced. The maximum peripheral speed for solid cast-iron disc wheels should not exceed 100 ft. per sec. and for cast-steel wheels of the same type, it should not exceed 200 ft. per sec.

19 Cast-steel wheels are usually more convenient on account of their smaller size for the same flywheel effect, and cheaper because less additional bearing surface is required, and the greater cost per pound of material, if any, is offset by the lighter weight, the flywheel effect varying with the square of the radius of gyration.

20 The regulation due to any given flywheel effect can be computed by means of the formula

$$d = \frac{800{,}000 \times N \times T}{n^2 \times Wr^2}$$

It must usually be modified, however, and to show clearly how this comes about, the derivation of this formula is given herewith, following which are given the symbols for the quantities used.

21 The energy of a rotating mass is $\frac{Mv^2}{2}$. If the peripheral velocity of the mass M is reduced from v_2 to v_1 it will lose energy amounting to

$$\frac{M\ (v_2^2 - v_1^2)}{2}$$

Factoring $(v_2^2 - v_1^2)$,

$$(v_2^2 - v_1^2) = (v_2 + v_1)\ (v_2 - v_1)$$

Substituting in the above and multiplying by $\frac{v}{v}$ we have

$$\text{Energy lost} = \frac{Mv\ (v_2 + v_1)}{2} \times \frac{(v_2 - v_1)}{v}$$

but

$$\frac{v_2 + v_1}{2} = \text{average velocity} = V$$

and

$$\frac{v_2 - v_1}{v} = \text{relative change in velocity} \equiv d$$

(d is also called the per cent of ununiformity).

22 Substituting the values of V and d in the above equation of energy lost, we have

$$\text{Energy lost} = Mvvd = Mv^2d$$

or

$$M\,\frac{(v_2^2 - v_1^2)}{2} = Mv^2d$$

23 Referring to diagram (Fig. 1), let ordinates represent horsepower and abscissae represent time. Then the energy, $\frac{NT}{2}$ is that which must represent the amount given out by the rotating masses, after the turbine gates have been closed off, and T is the time required to give it up. That is, if the total load is taken off suddenly, the power would drop from a to b, but on account of the rotating masses this would not happen instantaneously, but would take a certain time T, and the effect of the masses is equal to the area below the line y, and if this is a straight line the area $= \frac{NT}{2}$. Then

$$\frac{NT}{2} \times 550 = \frac{W}{g}\left(\frac{\pi^2r^2n^2d \times 4}{60 \times 60}\right)$$

where

$$M = \frac{W}{g}$$

and

$$v = \frac{2\,\pi rn}{60}$$

Substituting numerical values and transposing, we have

$$Wr^2 = \frac{NT}{n^2d}\left(\frac{60 \times 60 \times 32.2 \times 550}{2 \times 3.14 \times 3.14 \times 4}\right) = \frac{NT}{n^2d}\;800{,}000 \ldots\ldots\ldots [1]$$

and

$$T = \frac{Wr^2\,n^2\,d}{N \times 800{,}000} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

also

$$d = \frac{800{,}000 \times N \times T}{n^2 \times Wr^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

which is the formula as first given, and

Wr^2 = moment of inertia of the rotating masses in lb. ft. squared

T = time in seconds to close or open gates by the governor

n = revolutions per minute

$$d = \frac{V_2 - V_1}{v} = \frac{n_2 - n_1}{n} = \text{the relative change of speed}$$

$$= \frac{(D\, w)}{w}$$

$$w = \frac{\pi n}{30} = \text{angular velocity}$$

N = horsepower

Correction. In deriving the above formula, it was assumed that the line y was a straight line and the area under it was equal to $\frac{NT}{2}$, under the assumption that the total load was thrown off.

24 However, the friction load of the turbine and generator remains, and the actual area represented will be that under a curve $f(y)$. The effect of this friction load will, of course, be different depending upon the various types of turbines used, but the original formula may be modified safely as follows, the curve $f(y)$ being approximately a parabola:

$$d' = 0.8\, d \quad \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

25 Another cause which should be taken into consideration, providing the turbine is properly designed so as to give its maximum efficiency at normal or synchronous speed, is that the efficiency is reduced with either increasing or decreasing speed, which has the tendency to reduce still further the area under the curve $f(y)$. The amount reduced varies with the type of runner, being greatest for a high-speed, high-power runner, and least for a low-speed, low-power runner, since, if correctly designed and therefore following the laws of hydraulics, the change in efficiency will be greater for a high-speed than

for a low-speed runner for the same per cent of variation in speed. The formula modifying d' for this cause, is as follows:

$$d_{\text{eff}} = \frac{d'}{1 + \frac{d'}{\frac{n_1}{n_0} - 1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [5]$$

where $\frac{n_1}{n_0}$ varies from 1.8 for a runner of low speed to 1.3 for a runner of high speed.

26 Referring to the table of standard runners types A to F (Table 1, see end of paper), designed under the writer's direction for the Allis-Chalmers Company, the values of $\frac{n_1}{n_0}$ are as follows:

Type of Runner	A	B	C	D	E	F
Value of $\frac{n_1}{n_0}$	1.8	1.7	1.6	1.5	1.4	1.3
Specific speed $k = \frac{\text{r.p.m.}}{H} \sqrt{\frac{\text{h.p.}}{\sqrt{H}}}$	13.55	20.3	29.4	40.7	$\frac{49.7}{62.8}$	$\frac{70.97}{83.78}$

27 The specific speed is that speed in revolutions per minute of a turbine runner, diminished in all dimensions to such an extent as to develop 1 h.p. when working under the head H = 1 ft. This value is called type characteristic by Professor Zowski in his article in the Michigan Technic of June, 1908, The American High Speed Runners for Water Turbines.

28 To simplify calculations, this table will prove efficient:

Type of Runner....	A	B	C	D	E	F
$0.8x$ in $d_{\text{eff}} = 0.8x\ d$	0.714	0.703	0.69	0.671	0.645	0.606

29 For impulse turbines the same d_{eff} as for type A reaction runner should be used.

30 To find the speed variation for any other than a full load change, the following must be considered: If T is the regulating time for the total governor stroke or 100 per cent load of the turbine, it would appear that for 50 per cent load or stroke, the regulating time would be $\frac{T}{2}$, and for 25 per cent, $\frac{T}{4}$, etc.

REGULATION WITH MECHANICAL GOVERNORS

31 As far as the stroke is concerned, this is nearly true with a mechanical governor, and the speed variations for part load changes can be calculated as follows:

32 The formula for d which we have given, may be transformed to appear:

$$d = \frac{Z^2}{2\left[\frac{2\left(\frac{mv^2}{2}\right)}{550\ NT}\right]}\left[1 - \frac{2\ aZ}{3\left[\frac{2\left(\frac{mv^2}{2}\right)}{550\ NT}\right]}\right]$$

33 In which the new symbols Z and a are, respectively, the change in load, and the remaining load.

34 If we let

$$S = \frac{1}{2\left[\frac{2\left(\frac{mv^2}{2}\right)}{550\ NT}\right]}$$

in the foregoing formula, it will appear as follows:

$$d = SZ^2\left(1 - S\frac{4\ aZ}{3}\right) \qquad [7]$$

35 From this formula, we can now compute d for various part loads, since S, as may be readily seen, is d as figured from the original formula for total change of load, or $S = d'_{\text{eff}}$ in the above formula, and for load changes of 25%, 50% and 75% we have the following:

a For 25%, $Z = 0.25$ and $a = 0.75$
$d'\ 25\% = d'_{\text{eff}} \times 0.625\ (1 - d_{\text{eff}} \times 0.25)$

b For 50%, $Z = 0.50$ and $a = 0.50$
$d'\ 50\% = d'_{\text{eff}} \times 0.25\ \ (1 - d'_{\text{eff}} \times 0.333)$

c For 75%, $Z = 0.75$ and $a = 0.25$
$d'\ 75\% = d'_{\text{eff}} \times 0.56\ (1 - d'_{\text{eff}} \times 0.25)$

36 The results of these computations plotted appear as in Fig. 2, in the line marked *a*.

37 Line *a* correctly represents the speed variation under the assumption that the governor acts instantaneously upon a speed change;

however, a certain speed change must occur before the governor can act on account of the insensitiveness of the flyballs, and the actual speed changes are more correctly represented by a line *b*, midway between the curve *a*, and a straight line *c*, as shown.

REGULATION WITH HYDRAULIC GOVERNORS

38 For a hydraulic governor, an entirely different line of reasoning must be followed. My own observations are supported by those of others who claim that the regulating time for all gate openings is nearly constant and equal to that of the total gate opening for a hydraulic governor.

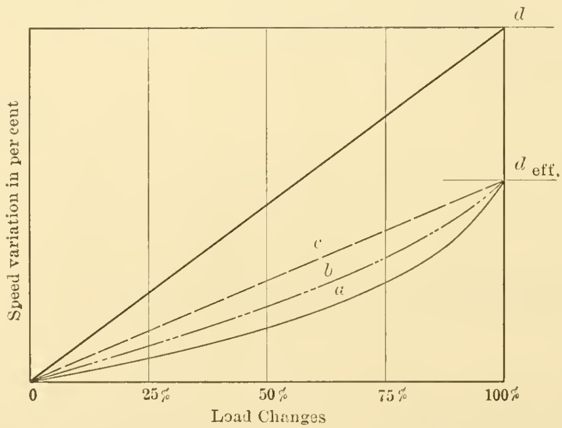


FIG. 2 APPARENT AND ACTUAL REGULATION OF MECHANICAL GOVERNOR

39 This is due largely to the throttling effect of the regulating valve and the time required to overcome the inertia of the regulating masses. That this fact is not detrimental to the speed regulation can be seen from what follows, and that it is of large benefit to the problem of pressure variations and therefore indirectly again to regulation, will be seen from a study of the following discussion on pressure variations.

40 From experience and tests, it has been found that for hydraulic governors the curve *a*, shown under partial load speed variation for mechanical governors, must be modified as shown in Fig 3.

41 The curve *d* is an arc of a circle drawn tangent to the line *od* which is the line of apparent regulation, and through the point d_{eff} which is the actual value of d' as modified for various causes as given.

42 It would appear from a comparison of the regulation curves

given that the speed variation would be less for partial loads with the mechanical governor than with the hydraulic governor. This, however, is not true for practical purposes, since the regulating time for any but very small mechanical governors is, of necessity, very great compared with the hydraulic governor, the regulating time of which can practically be made as short as desired for any size. From an investigation of the original formula for d, it can be seen that d varies directly with T, and therefore, if we can use a shorter time T, with the hydraulic governor than with the mechanical, it is seen that the apparent advantage can be overcome many times, due to the very short time T, possible.

43 A mechanical governor can perform only a definite amount of work per unit of time, depending upon the size and strength of the

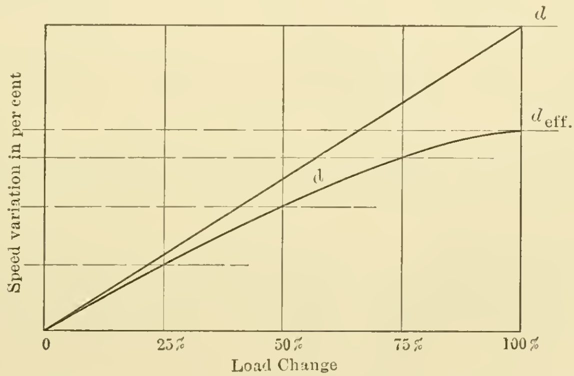


Fig. 3 Apparent and Actual Regulation of Hydraulic Governors

driving belt or gears which must transmit the power of the governor. If for instance, a mechanical governor is capable, due to the strength of its parts, to transmit 1 h.p. = 550 ft. lb. per sec., and the work required to regulate a turbine is 11,000 ft. lb., then the regulating time must be $\frac{11,000}{550} = 20$ sec.

44 The work which a hydraulic governor is capable of doing, is a question of the size of the regulating cylinder, and the time in which it can do this work depends upon the time in which sufficient oil can be brought to the cylinder. This time again depends upon the pressure in the pressure tank and the size and discharge coefficient of the oil pipes and the regulating valve.

REGULATION OF ENCASED TURBINES

45 If the water is conducted to the turbine in a long penstock (encased turbine) a large amount of energy is stored in the moving column of water and a change in its velocity involves a change in its kinetic energy and produces pressure variations, which may, if an attempt is made at too rapid regulation, leave the turbine deficient in energy when increased power is desired, or when the power is decreased, may produce such shocks as will seriously affect regulation, or perhaps result in serious injury to the penstock or turbine.

PRESSURE VARIATIONS

46 With open-flume turbines, these pressure variations may be disregarded, but with encased turbines they must always be carefully considered. These variations can never be done away with entirely in practical cases, but they can be minimized to almost any extent by proportioning properly the various parts of a plant. The solution of such a problem is generally determined by commercial considerations, and a balance must be struck between cost of penstocks and cost of flywheels, if it is impossible or undesirable to modify conditions with other appurtenances.

47 Pressure variations to a greater or less extent, occur in every practical turbine installation, whenever the amount of water which flows to the turbine is varied, as in the case of a change of load. However, for practical considerations, as far as regulation of speed with governors is concerned, these variations can be considerable before they will have any appreciable effect on the speed regulation. In modern plants, where the tendency usually is to develop as much power and head as possible in a single plant, it frequently becomes necessary to carry the water for some distance in flumes, pipe lines or tunnels in order to concentrate the head on the plant. The length of the conduits often becomes many times greater than the head, and as such long conduits become a large factor in the cost of the plant, the natural tendency is to reduce the size of conduit and increase the velocity of the water flowing in or through it. However, head, length of conduit, and velocity of water in the conduit, are the three principal factors that produce pressure variations, and their relation to each other, as well as their effect on regulation of speed, becomes a very important problem in such plants.

48 In such a plant, the effect of the flywheel masses is the same as before, and the same theory and formulae apply to it. However,

instead of a constant head acting on the turbine, we will have a variable head, which may become greater or less than the normal, depending upon the change of load. This variation in head tends to increase or decrease the amount of power which would be developed for the same gate opening at normal or constant head, and the tendency of the flywheel effect to keep the speed constant is lessened by the amount of increased or deficient power so caused.

49 As calculated from the foregoing formula, "d effective" must be modified by the following formulae due to the causes above mentioned.

For closing gates

$$d''' = d_{\text{eff}}\left(1 + \frac{(D\,H)}{H}\right)^{\frac{3}{2}} \qquad [8]$$

For opening gates

$$d''' = \frac{d_{\text{eff}}}{\left(1 - \frac{(D\,H)}{H}\right)^{\frac{3}{2}}} \qquad [9]$$

The derivation of these formulae and the theory leading up to them are herewith given.

50 We know, from the fundamental axioms of mathematical physics, that a given mass acted upon by a variable force in an interval of time is accelerated or decelerated. This relation is given by the following fundamental equation

$$M\frac{\mathrm{d}v}{\mathrm{d}t} = P$$

and

$$M\mathrm{d}v = P\mathrm{d}t$$

51 In the problem relating to speed regulation we always deal with a fixed time T, and a variation in the velocity of the water brought about in the time T, which is identical with a pressure variation. We may, therefore, write

$$M(Dv) = (DP)\,t$$

where

$$M = \text{mass} = \frac{W}{g}$$

in which

W = weight in lb.

$$g = 32.2 = \text{acceleration of gravity}$$

and

$$P = \text{pressure} = Hy$$

in which

$$\frac{P}{y} = (DH), \text{ where } y = \text{specific weight}$$

Let L represent the length of a pipe line or penstock and F its area. Then

$$M = \frac{LFy}{g}$$

$$P = FP = Fy\,(DH)$$

And substituting in the equation $M(Dv) = (DP)t$, we have

$$\frac{LFy}{g}\,(Dv) = Fy\,(DH)T$$

Transposing

$$(DH) = \frac{L(Dv)}{gT} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [10]$$

or the actual increase or decrease of head for certain regulating time T, and a variation of the velocity of the water of (Dv).

52 This formula, to express the result in per cent of the total head, will read

$$\frac{(DH)}{H} = \frac{L(Dv)}{gTH} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [11]$$

and for both increase and decrease it will read

$$\frac{(DH)}{H} = \pm\frac{L(Dv)}{HgT} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [12]$$

where $+$ is for closing and $-$ is for opening gates.

53 From this formula we learn that the pressure variations vary directly with the length of the penstock and the velocity of the water in it, and inversely as the head and the time during which the original velocity is varied by (Dv).

54 If we assume an allowable pressure variation, $\frac{(DH)}{H}$, the regulating time can be found from a transposition of the above formula, as follows:

$$T = \pm \frac{L(Dv)}{Hg\frac{(D\,H)}{H}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad [13]$$

As an example, let

$$\begin{aligned} L &= 500 \text{ ft.} \\ H &= 100 \text{ ft.} \\ V_0 &= 100 \text{ ft per sec. for } T = O \\ v_1 &= 5 \text{ ft. per sec. for } T = 2 \text{ sec.} \\ (Dv) &= v_0 - v_1 = 5 \text{ ft. per sec.} \end{aligned}$$

Then

$$\frac{(DH)}{H} = \pm \frac{500 \times 5}{100 \times 32.2 \times 5} = \pm\, 0.39 = \pm\, 39\%$$

which shows that for a change in penstock velocity of 5 ft. per sec. the pressure would increase or decrease 39 %.

55 Where a pressure variation not to exceed 10% is permissible, $\frac{(D\,H)}{H} = 0.10$, and the corresponding regulating time for the same conditions must be

$$T = \pm \frac{500 \times 5}{100 \times 32.2 \times 0.10} = 7.8 \text{ sec.}$$

which shows that it takes 7.8 sec. to accelerate or decelerate the velocity by 5 ft. in order not to increase or decrease the pressure to exceed 10 %.

56 As may readily be noted, the above formula gives equal results for increase or decrease of pressure, and both values become infinity if any of the factors in it become infinity or zero. It is impossible, however, to imagine the pressure decrease to become infinity; it is evident that the decrease can never exceed 100% and if this limit is surpassed, or even reached, the liquid column must sustain a rupture, and the water will flow intermittently or in the form of pulsations. From this it is evident that the formula can be correct

only, if at all, within certain limits and under certain restrictions, and then only approximately, as we will see from our further discussion.

57 The above indicates that we must analyze this problem further in order to get formulae which will cover the ground and give more exact results.

58 It is a well-known fact that if penstock conditions are disturbed by moving a gate anywhere in the line, either at the upper or lower end or intermediately, the whole system becomes oscillatory, which means that the pressure and velocity in the penstock are oscillating.

59 A similar phenomenon can also be experienced in an open flume in which water is flowing. Assume that the gate at the lower end of such a flume is closed. A wave will be produced next to the gate, and this will proceed upward along the flume with a certain velocity, until it disappears either in the intake basin, where v nearly equals zero, or it will be dissipated by friction on the flume walls, depending upon the length and roughness of the flume and the velocity of the wave.

60 In closed flumes or penstocks, such waves do not disappear so quickly, the surface friction being small in comparison with the velocity and the produced force, and its influence may even be neglected.

61 It is evident that these waves, or rather vibrations, are liable to interfere with each other and consequently affect the pressure in the penstock. It is therefore of greatest importance to determine the velocity with which these vibrations travel in and along the penstock.

VELOCITY OF VIBRATIONS

62 This velocity of the vibrations, which we will indicate by C in our further discussion, depends (a) upon the compressibility of the liquid, and (b) upon the nature of the material of which the penstock consists.

63 It is a well known fact that vibrations in water proceed with the same velocity as does sound, and if the walls of the flume or penstock can be considered absolutely rigid, C therefore depending only upon the compressibility of the water, the velocity of the vibrations will be 4650 ft. per sec., or, as already stated, the same as that of sound. The penstock walls, however, are always flexible to a certain degree, depending upon the elasticity of the material from which they are constructed, and therefore they also exert a certain influence upon the vibrations.

64 Under the influence of pressure variations, the penstock walls, due to their property of elasticity, expand and contract in a rather remarkable degree, called "breathing" of penstocks. Due to this breathing, the velocity of vibration is reduced, the motion so produced naturally having a damping effect upon the vibrations, the same as any other obstruction would have. The velocity of 4650 ft. per sec. may therefore be considered a maximum with which any vibrations in the penstock will proceed.

65 The actual velocity of the vibrations can be computed by means of the following formula:

$$a = \sqrt{\frac{\frac{g}{y}}{\frac{1}{e} \times \frac{1}{E} \times \frac{D}{d}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [14]$$

where

g = acc. of gravity = 32.2 ft. sec.^{2}

y = specific weight of water = 62.4 lb. ft.^{3}

$\frac{1}{e}$ = elasticity of the water, e = 42,000,000 lb. ft.^{2}

$\frac{1}{E}$ = elasticity of penstock material in lb. ft.^{2}

D = diameter of penstock in ft.

d = thickness of penstock wall in ft.

66 The value of E is variable for the same material and for different materials. The following average values have been taken from Kent's Mechanical Engineer's Pocket Book and from the German engineer's hand-book Hütte.

For steel plate, E = 28,000,000 lb. in.^{2} = 4.032.10^9 lb. ft.^{2}

For cast iron, E = 15,000,000 lb. in.^{2} = 2.16.10^9 lb. ft.^{2}

For wooden staves, E = 1,680,000 lb. in.^{2} = 2.42.10^8 lb. ft.^{2}

67 If we substitute the numerical values for g, y, and e, in formula [14] and, for the sake of brevity, place the letter $K = E^{-1} \times 10^{10}$ we will obtain

$$a = \frac{22{,}720}{\sqrt{23.5 - K \times \frac{D}{d}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [15]$$

68 The value of K can now be computed for the various penstock materials, and will be as follows:

Steel plates, K = 0.232

Cast iron, K = 0.464

Wooden staves, K = 41.50

69 Formula [14] was first derived by Lorenzo Allievi, C.E., of Rome, Italy, and published by him in 1903 in the Italian paper, Annali della Società degli Ingeneri ed Architetti, under the title Teoria a generale del moto perturbato dell' acqua nei tubi in pressione. In 1904, this article was translated into French under the title Théorie générale du mouvement varié de l'eau dans les tuyaux de conduite, in the French paper Revue de Mécanique.

70 Based on the foregoing formula and values for K, Table 8 (see end of paper), giving values of a, has been computed, and includes diameters of pipes from 1 ft. to 20 ft. with thickness of walls from $\frac{1}{4}$ in. to 5 in.

71 For practical use, at least for preliminary purposes, or when the table is not at hand, the value of a can be taken as 3300 ft. per sec. for customary diameters and thicknesses of penstocks.

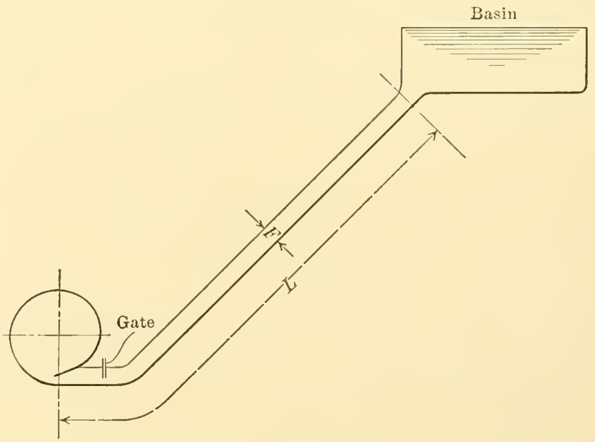


Fig. 4 Penstock Conditions Resulting in Pressure Variation

72 The effect of the velocity of vibrations upon the pressure variations depends upon the regulating time T, as will be seen from the following discussion.

73 If we assume a penstock of length L, as shown in Fig. 4, with a basin at its upper end and a gate at the turbine, the water with the gate open will have a velocity v. If the gate is closed, we have a variation in the velocity, with corresponding pressure variations and vibrations. As shown above, the vibrations will travel along the pipe line with a velocity a, and will reach the basin in a time, $t = \frac{L}{a}$. If the basin is sufficiently large, that is, if its area is many times that of the penstock, then the hydro-dynamic reaction, due to the large body

of water, is the cause of a new series of vibrations which proceed down the penstock with the same velocity a, as before, and the gate is again reached by them in the time, $t = \frac{2L}{a}$.

74 These reproduced waves coming from the basin will interfere with the waves traveling upwards and have the tendency to diminish the resulting pressure variations in all sections of the penstock, therefore also those in the gate area. This would indicate the following:

a Up to the time $t = \frac{2L}{a}$ $\left(\text{period } t = o \text{ to } t = \frac{2L}{a}\right)$, the pressure in the gate area is constantly increasing as if the penstock were indefinitely long. (See Fig. 5.)

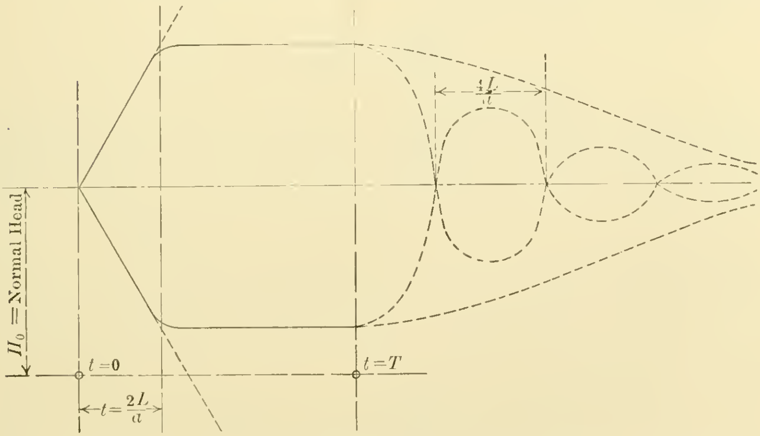


Fig. 5. Effect of Time during which a Change in Penstock Conditions is Affected

b Starting from the moment $t = \frac{2L}{a}$ the pressure variations are weakened by the retroceding waves or vibrations, and we conclude that the pressure must rest constant from the time $t = \frac{2L}{a}$ until the gate stops in its travel, ($t = T$), as both series of vibrations have an equal effect on the pressure.

c When the gate is stopped in its travel, ($t = T$) we get different conditions depending upon whether it is fully or partially closed. If it is fully closed, fluctuations will occur having a period of $\frac{4L}{a}$, but these will become smaller and smaller until the original pressure is reached.

75 If the gate area is only partially closed in the time $t = T$, the pressure rise will decrease asymptotically, since the column of water still keeps moving, but with a changing velocity.

76 Only the period from $t = o$ to $t = \frac{2L}{a}$ will be of interest to us in this discussion, since during this the maximum pressure rise or drop occurs.

77 The graphical illustration given in Fig. 5 explains our reasoning more clearly. From the point $t = o$ to $t = \frac{2L}{a}$, the pressure is constantly increasing or decreasing. From the point $t = \frac{2L}{a}$ to $t = T$ the pressure remains constant.

CRITICAL TIME

78 From the above, we see at once that it would be working against desired results should we choose a regulating time T for a governor less than the value $\frac{2L}{a}$, without awaiting the weakening effect of the reflected waves which arrive at the gate in the time $\frac{2L}{a}$.

79 Therefore, the governor regulating time T should always be greater than the time $t = \frac{2L}{a}$.

80 To show this fact just stated more clearly, we will consider both cases:

$$(a) \quad T < \frac{2L}{a}$$

and

$$(b) \quad T > \frac{2L}{a}$$

81 As we have already shown, if the gate is closed in a time $< \frac{2L}{a}$, the pressure rises as long as the gate is kept moving, and if the gate is totally closed, we will obtain the maximum possible pressure obtainable in a penstock.

82 This maximum pressure can be computed by means of the formula:

$$H_{\max} = H_o + \frac{av}{g} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad [16]$$

where

H_0 = initial head
v = velocity in the penstock
g = acceleration of gravity

83 This formula shows us that every change in velocity of 1 ft. means an increase or decrease in head of

$$\frac{a \times 1}{g} = \frac{3300 \times 1}{32.2}$$

$$= \text{about } 100 \text{ ft. if } T < \frac{2L}{a}$$

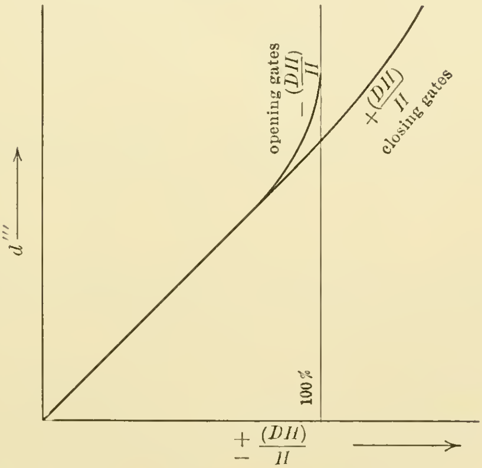


Fig. 6 Limit of Pressure Variations

84 From the example which we have considered under formula [13] we have

$$v_0 - v_1 = 5 \text{ ft.}; H = 100 \text{ ft.}; L = 500 \text{ ft.}$$

$$T = \frac{2L}{a} = \frac{2 \times 500}{3300} = 0.3 \text{ sec.}$$

$$H_{max} = 100 + \frac{3300 \times 5}{32.2} = 600 \text{ ft.}$$

which indicates that the pressure would rise from 100 ft. to 600 ft. if we closed the gate completely in the time $t = \frac{2\,L}{a} = 0.3$ sec.

85 The time $t = \frac{2L}{a}$, therefore, represents a *critical time*, which

should always be calculated, and the governor regulating time chosen as much greater as other conditions will permit.

86 If we now compare formula [10] originally derived for a maximum pressure rise, with formula [16] we obtain a difference for H_{max} as follows:

From formula [10]

$$\frac{(DH)}{H} = \frac{500 \times 5}{100 \times 32.2 \times 0.3} = \text{about } 2.6 = 260\%$$

$$(DH) = 260 \text{ ft.}$$
$$H_{max} = 100 + 260 = 360 \text{ ft.}$$

as compared with 600 ft. as obtained from formula [16]. This clearly illustrates the importance of considering the effect of the vibrations and elasticity of the water as well as the elasticity of the penstock walls.

87 It is evident that the theory by means of which formula [16] is derived, shows the maximum value of H, as for the period

$$t = o \text{ to } t = \frac{2\,L}{a} \text{ or } \left(T \leqq \frac{2\,L}{a}\right)$$

it is immaterial in what time the kinetic energy is stored in the penstock. If we close the gate completely, the same energy is stored up, whether the gate is closed in 0.1 sec. or 0.3 sec.

88 As has already been shown, for a closing time, $T > \frac{2\,L}{a}$, the pressure rise is constant, and this constant pressure increase or decrease represents the maximum possible value for such a regulating time, and may be calculated by means of the following formula:

$$\frac{(DH)}{H} = \frac{n}{2}\left(n \pm \sqrt{n^2 + 4}\right) \ldots\ldots\ldots\ldots\ldots [17]$$

true for the period

$$t = \frac{2\,L}{a} \text{ to } t = T$$

where

$$\frac{DH}{H} = \text{pressure variation}$$

$$\frac{DH}{H} \times 100 = \text{pressure variation in per cent}$$

$$n = \frac{Lv}{gHT} = \text{formula} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [10]$$

Use + sign for closing gates and − sign for opening gates.

89 This formula [17] is most important in our calculations, since it gives us the momentary head under which a turbine must operate during a load change for any given regulating time.

90 The results of this formula plotted graphically give us two curves one for increase of head and one for decrease of head. For an increase, if n = infinity, $\frac{(DH)}{H}$ = infinity; for a decrease, if n = infinity, $\frac{(DH)}{H}$ will asymptotically reach the value 1. (See Fig. 6.)

91 It will be noted that formula [17] contains just those factors which we missed in formula [10]. According to formula [10], our results, if plotted, would appear along the straight line as shown, practically midway between the two curves, $+\frac{(DH)}{H}$ and $-\frac{(DH)}{H}$. (See Fig. 7.)

92 We note further that for a regulating time greater than $\frac{2L}{a}$ and variations of pressure not exceeding 20 to 25%, formula [10] may be used approximately. For larger variations, the difference between $+\frac{(DH)}{H}$ and $-\frac{(DH)}{H}$ becomes considerable, and formula [17] must be used even for approximate results.

93 Tables 3 to 8 (See end of paper) have been computed from formula [17] and are based on different values of $\frac{L}{H}$, (where L is the length of the penstock and H the effective head), and for velocities up to 20 ft., each table giving the pressure variations both $+\frac{(DH)}{H}$ and $-\frac{(DH)}{H}$ for a given regulating time T.

94 These tables will be found of great benefit in determining quickly the regulating time and the corresponding pressure variations for different penstock diameters, providing L and H are given, as they are in practically every case. But, in determining or assuming the regulating time, it must be remembered that it must always be greater than $\frac{2L}{a}$.

95 Referring to the tables and the case already used to illustrate, namely, L = 500 ft., H = 100 ft., v = 5 ft. and T = 2 sec.

$$\frac{L}{H} = \frac{500}{100} = 5$$

$$\frac{(DH)}{H} = +0.471 \text{ and } -0.32 = 47.1 \text{ and } 32 \text{ per cent}$$

From formula [10] we would obtain

$$\frac{(DH)}{H} = 39 \text{ per cent}$$

as the approximate average value of the exact results. The tables permit of interpolation.

96 It now becomes necessary to analyze the effect of the pressure variations on the speed regulation.

97 As already stated, if the regulating time, T is chosen greater than $\frac{2L}{a}$ the pressure rise or drop, and therefore the head remains constant and its maximum value may be calculated from formula [17], according to which the tabular values are found. We may therefore, assume that the turbine is operated at a constant head during any load change, the head varying for different per cent of changes; and the head for any part load change may be found by substituting the new penstock velocity in formula [17], or from the tables direct.

98 From formula [3] we see that d is directly proportional to N (= h.p.) the load. Therefore, if the head is varied the capacity varies as $\sqrt{H^3}$ (h.p. varies as the square root of the head cubed) and for a new head $= \left(H + (DH)\right)$ the capacity of the turbine rises with $\left(H + (DH)\right)^{\frac{3}{2}}$ and the new capacity of the turbine is $N\left(H + (DH)\right)^{\frac{3}{2}}$, which is the case when load is thrown off.

99 When the load is thrown on the available energy decreases with the term

$$\frac{1}{\left(H - (DH)\right)^{\frac{3}{2}}}$$

100 To obtain the results in per cent, these terms are transformed as follows:

For closing gates,

$$\left(1 + \frac{(DH)}{H}\right)^{\frac{3}{2}}$$

and, for opening gates,

$$\frac{1}{\left(1 - \frac{(DH)}{H}\right)^{\frac{3}{2}}}$$

so that finally we get a speed variation d modified by pressure variations $\pm \frac{(DH)}{H}$ as given by the following formulae:

For closing gates (load thrown off)

$$d''' = d_{\text{eff}} \left(1 + \frac{(DH)}{H}\right)^{\frac{3}{2}} \qquad [18]$$

for opening gates (load thrown on)

$$d''' = \frac{d_{\text{eff}}}{\left(1 - \frac{(DH)}{H}\right)^{\frac{3}{2}}} \qquad [19]$$

101 After making a number of calculations according to these formulae, it will be noted that the results from both are practically identical within certain limits. That they are not identical throughout the range of the pressure variation tables can be seen from the following:

For

$$-\frac{(DH)}{H} = 1 \ (100\%)$$

$$d''' = \frac{d_{\text{eff}}}{(1-1)^{\frac{3}{2}}} = \text{infinity}$$

whereas for

$$+\frac{(DH)}{H} = 1$$

$$d''' = d_{\text{eff}}\,(1+1)^{\frac{3}{2}} = \text{a definite value}$$

102 This shows us that, up to a point where $\frac{(DH)}{H} = \pm 1$, the results for d''' are practically identical for opening or closing the gates. Then the d''' curve turns up for opening and becomes infinity with $-\frac{(DH)}{H} = 1$, while the d''' curve for closing gates goes on undisturbed as shown by the accompanying diagram, (Fig. 6).

103 This indicates that for practical problems, where $-\frac{(DH)}{H}$ would never be allowed to reach the value of 1, it is not necessary to calculate d''' for both opening and closing gates, but that either one of the formulae [18] and [19] will give the desired results. As $-\frac{(DH)}{H}$ approaches 100%, d''' for opening gates becomes considerably greater

than d''' for closing gates. In such cases, it is well to calculate d''' for both movements, particularly as frequently it is not necessary that d''' for opening gates be as low as d''' for closing gates.

104 From observation of the tables on pressure variations, it will be noted that a change in velocity of 1 ft. will have considerable effect on the pressure variation, and this velocity should always be kept as low as is consistent with a reasonable investment. We should always keep in mind that by decreasing our penstock velocities, we not only help our pressure variations, and hence speed regulation, but use the water more economically, since our friction head will be less as the velocity becomes less.

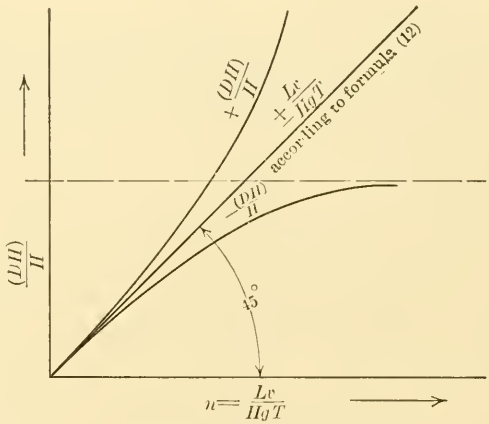


FIG. 7 COMPARISON OF PRESSURE VARIATIONS FOR RIGID AND FLEXIBLE PENSTOCKS

PRESSURE REGULATOR

105 If a reasonable solution cannot be found in the foregoing, such as will satisfy both engineering and commercial conditions, or either, it will become necessary to consider one or more practical appurtenances which are discussed in what follows. Economically, it will often prove desirable to consider these, even if not necessary to a solution of the problem from an engineering point of view.

106 A pressure regulator is a device attached to the turbine casing or penstock near the turbine, and operated from the governor in such a manner that when the turbine gates are closed suddenly and a sufficient amount to disturb the regulation on account of pressure rise, the regulator will be opened by the governor, sufficiently to keep the pres-

sure rise within reasonable limits. Such a pressure regulator should be adjustable so that the amount of pressure rise for any given load change can be predetermined for any set of conditions. It should close automatically and slowly under usual conditions so that its sudden closure will not produce a pressure rise. It should, however, be so arranged, that if a sudden increase should occur after a sudden decrease in load during which the regulator is opened, the governor will close the regulator quickly and positively. Otherwise water then needed to prevent an excessive pressure drop would pass through the regulator while it was slowly closing. Such pressure regulators can be designed practically, with all the functions described, and if of sufficient size the maximum pressure rise will not exceed 10% above normal with a load change of 100%. It will be seen from our subsequent discussion that for a fixed set of conditions, the pressure drop is always less than the pressure rise, which at once shows us the value of the pressure regulator.

107 From tests made by the writer and substantiated by others, the pressure rise in a turbine, and consequently in the penstock feeding a turbine, depends directly upon the discharge capacity of the pressure regulator, if properly designed, and upon the sensitiveness of the operating mechanism of the pressure regulator. The latter should be adjustable, so that the pressure regulator can be set to meet the requirements of any fixed conditions after being installed.

108 If the sensitiveness of the pressure regulator is 10%; that is, if the operating mechanism is so adjusted that it will open if a sudden load change amounting to 10% of the total load occurs, the pressure rise will be as follows:

Discharge capacity, 100% of turbine discharge, pressure rise 10%
Discharge capacity, 75% of turbine discharge, pressure rise 20%
Discharge capacity, 50% of turbine discharge, pressure rise 30%

109 Due to the insensitiveness of the operating mechanism, the pressure rise will be the same regardless of the load, and will be even slightly greater for a small load change than a large one, as it will take proportionally more time to open sufficiently to pass the small quantity of water. Another factor which helps to bring this about is the discharge coefficient of the pressure regulator, as this is greater the larger the opening. In calculating the effect on the speed regulation of the pressure rise, it is therefore necessary to take this into consideration for a partial load change as well as a full load change.

110 As already explained, although $-\frac{(DH)}{H}$ is always less than $+\frac{(DH)}{H}$, the corresponding regulation as affected by these pressure variations is practically the same, at least within the usual limits. If this is the case, it would appear that a pressure regulator is of no value in improving speed regulation. However, in most plants the load is thrown off much more suddenly than it is thrown on, the few exceptions usually occurring in small plants which always require more careful consideration with respect to the subject of speed regulation.

111 A lighting load is usually turned on as suddenly as turned off, but its proportion to the total load is exceedingly small, a few lights usually being turned on at a time. Motor loads are usually turned on very slowly by means of resistances or otherwise, and such sudden loads as may come on the motor during its operation are generally only a small part of the total load. On the other hand, a motor load is usually thrown off suddenly, whether purposely or accidentally, so that it becomes more difficult to maintain constant speed for load thrown off than for load thrown on, and it is of great benefit to have conditions for good regulation better for that case.

112 This benefit is obtained by means of the pressure regulator, as $+\frac{(DH)}{H}$ may be reduced to such an extent that its effect on the speed regulation is very small.

113 It is of course evident that a pressure drop of less than 100% is not dangerous to the penstock, whereas a pressure rise much less than 100% may be very dangerous, particularly if it occurs frequently. In this case it is liable to crystallize the penstock material, especially at the rivetted joints, so that the penstock may give way with a pressure rise much within the limit set by the original factor of safety. In such a case, the pressure regulator not only assists in the regulation of speed but protects the penstock as well.

114 When a pipe line or penstock is laid over a rough country, or where it descends precipitous hillsides after running along a comparatively gentle slope, care must be taken that the water will never be accelerated so quickly at a change in slope that the water column can break and thus exceed or even approach the maximum pressure drop of 100%. In such a case the penstock is in danger either of collapsing or of being shattered by a possible water ram.

115 It is uncommercial to provide against something that may never happen and if the greatest load change ever expected under normal operation is 25%, it would be a waste of money to provide for 100% change of load, as far as speed regulation is concerned.

116 Yet it is always necessary to consider the effect of the maximum pressure rise for 100% load change, since in the case of a short circuit or break in the governor such an extreme load change may occur and subject the penstock to the corresponding pressure rise.

117 It may therefore be desirable to install a pressure regulator simply to protect the penstock with entire disregard of the regulation, which may be commercially satisfactory without it.

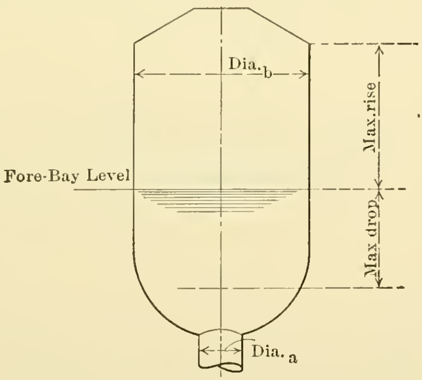


FIG. 8. PRACTICAL DESIGN FOR A HIGH STANDPIPE

EQUALIZING RESERVOIR AND STANDPIPE

118 As has just been stated above, the pressure drop is always less than the pressure rise, and as long as the pressure drop is within such limits as will permit satisfactory regulation, the pressure rise can be kept within safe limits by means of the pressure regulator. When, however, the point is reached where the pressure drop is excessive, the problem is again altered. The practical solution of such a problem is by means of an "equalizing reservoir," or a "standpipe." The effect of either is the same, namely, to reduce the effective length of the penstock, and to supply or take up water during a change of load, while the flow of the same amount of water will be accelerated or retarded in that portion of the penstock beyond the reservoir or standpipe. In small plants the equalizing reservoir is seldom used, as the

same effect can be had cheaper with a standpipe. However, in large plants under medium heads, where the quantity of water used is considerable, the reservoir will usually prove more economical in first cost and of much greater benefit to pressure variations and hence to speed regulation. The larger the surface area of a reservoir or standpipe, the smaller will be the pressure variation, which at once shows the advantage of the reservoir.

119 The topography of the country surrounding a power site usually decides whether a reservoir or standpipe should be used, as entirely artificial reservoirs may prove very expensive, and in such cases the standpipe is resorted to. It will be often found advantageous to change the shortest or most economical route of the pipe line to one more circuitous, in order to use a natural reservoir site, or to bring

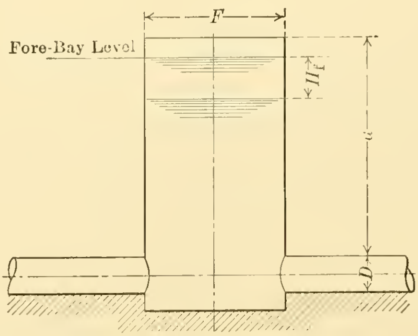


FIG. 9 MINIMUM DIMENSIONS OF A STANDPIPE

either the reservoir or the standpipe closer to the power house. If the standpipe is of suitable diameter and close to the turbine, the speed regulation will approach that obtainable with an open flume. Otherwise the problem becomes that of a plant with a closed penstock, of a length equal to that of the draft tube, plus the length of the penstock from the turbine to the standpipe, plus the height of the standpipe itself. To approach more nearly the effect of regulating reservoirs, high standpipes should have their upper part enlarged, in the shape of a tank (Fig. 8). This tank may be supported on structural steel columns. The pipe leading to this tank should be of a diameter not less than that of the penstock. Where a power house is located near a gently sloping hillside, the standpipe may be laid up this hillside and supported by it, instead of being supported by columns or

otherwise. Standpipes for heads of a thousand feet have thus been built.

120 The standpipe should be located as near the turbine as possible as has been previously stated. If it is arranged with an overflow, the pressure rises can be practically eliminated, and the pressure drop will depend directly upon the size or capacity.

121 The minimum height of such a standpipe is determined by the restriction that in no case must the water level in it drop to such a point as would admit air into the penstock. This condition is satisfied by the following equations (Fig. 9):

$$a > \sqrt{\frac{Q}{F} \times \frac{L \times v}{g}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [20]$$

$$a \geqq D + Hf \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [21]$$

Where

Q = cu. ft. per sec.
F = area of standpipe in sq. ft.
L = pipe line length above standpipe in ft.
v = pipe line velocity in ft. per sec.
Hf = friction head in ft.
D = diameter of penstock in ft.

122 It is seldom satisfactory to have the standpipe overflow and furthermore it is not economical. They are usually built high enough so that the water cannot overflow, even with a maximum load change. In northern climates, where there is danger of freezing, the entire standpipe should be well lagged and quite often it must be provided with steam-pipe coils, supplied with steam from a boiler installed at the foot of the standpipe.

123 In order to reduce the height of the standpipe as much as possible, the slope of the pipe line should be as little as is consistent with the velocity head and friction head required, as the top of the standpipe must in any case be higher than the level of the water in the forebay to meet the conditions of a shutdown with pipe line full.

124 If load is suddenly thrown on, a certain time will elapse before the water accelerates in that part of the pipe between the standpipe and the turbine, another and longer time elapses before the water in the part of the pipe above the standpipe accelerates to the velocity required by the new load. During the latter time, the stand-pipe must supply the turbine with a quantity of water which is the difference between that used by the turbine and that supplied by that part

of the pipe above the standpipe at the reduced velocity during acceleration. The reverse is true when load is thrown off.

125 The actions of the water in a plant with standpipe or equalizing reservoir are easily explained, but very difficult to compute. In the following will be found a practical method for calculating standpipe dimensions. No attempt is made to give the derivation of the formulae, as that in itself would require a paper of some length.

126 Let

L = length of pipe line between standpipe and intake
D = average diameter of pipe line in ft.
F_p = average area of pipe line in sq. ft.
F_s = average area of standpipe in sq. ft.
Q = water discharged by turbines in cu. ft. per sec.
v = average velocity of water in pipe line in ft. per sec.
y = drop of water level in standpipe when Q cu. ft. of water is flowing continuously
y_{max} = maximum drop or rise of water level
h_f = friction loss in ft. in the pipe line $= f\frac{L}{D}\frac{v^2}{2g} = av^2$
$a = \frac{fL}{D2g}$ = a function of the velocity, however assumed to be constant
f = friction coefficient = 0.015 for new plate steel pipe
g = 32.2 ft. per sec. = acceleration of gravity
Dy = change of level of standpipe
Dv = change of velocity in pipe line
Dt = time element in sec.

Then

$$Dy = \left(\frac{Q}{F_s} - \frac{F_p}{F_s}v\right)Dt \qquad [22]$$

and

$$Dv = \frac{g}{L}\left(y - av^2\right)Dt \qquad [23]$$

127 From these two formulae y can be computed for any time interval and the results plotted with time in seconds as abscissae and y in feet as ordinates.

128 The resulting curve (Fig. 10) shows the maximum drop or rise of the water level for any assumed or existing pipe line and standpipe combination.

129 If it is desired to approximate the proper capacity of a standpipe or equalizing reservoir in order not to exceed an assumed or desired pressure rise or drop, we must proceed as follows.

130 Referring to par. 54 we find the formula for the accelerating or decelerating time for a column of water as follows:

$$T = \pm \frac{Lv}{Hg \frac{(DH)}{H}}$$

$\frac{(DH)}{H}$ is the assumed or desired pressure rise or drop.

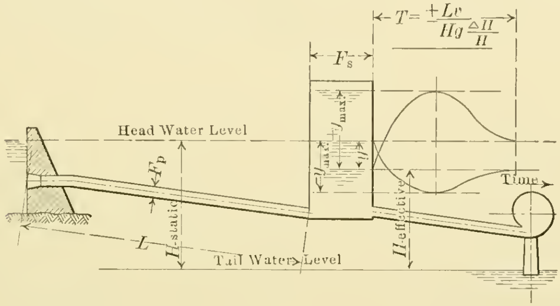


FIG. 10 PRESSURE VARIATIONS WITH STANDPIPE

131 If we now let S represent the governor opening or closing time, then the equalizing capacity $C = Q\ (T - S)$ in cu. ft. and the area

$$F_s = \frac{C}{h} \quad \text{[24]}$$

where

$$h = h_f + \frac{(DH)}{H}\left(H \pm h_f\right) \quad \text{[25]}$$

132 The theory from which these formulae result was first derived by Engineer Pressel and published by him in the Schweizerische Bauzeitung, January 1909, under the title Dimensionierung von Wasserschloessern.

133 A very thorough, though highly theoretical study of this subject was published in the same journal in 1908 by Prof. Franz Prasil, under the title of Wasserschlossprobleme.

134 Although not so economical in the use of water, it will often prove more economical in first cost of plant, to install a pressure regulator rather than build the standpipe to the height as found necessary by the preceding equations. With a suitable pressure regulator in the system, the height of the standpipe above the forebay water level is more or less a question of judgment, but if made equal to the depth, it will always prove sufficient. It should be remembered, however, that a pressure regulator is only a mechanical device, somewhat complicated, and many engineers would be unwilling to risk a catastrophe, in case of a sudden full load change with the pressure regulator out of order.

135 With the same purpose in view, namely, the reduction of the height of the standpipe, it may sometimes prove expedient to provide water rheostats connected to the low-tension bus-bars, with an oil switch in the connection. By means of a mechanical trip on the governor or gate mechanism the control circuit of the switch can be closed at any desired gate opening or power output, so that in case of a short circuit part of the load will be switched onto the water rheostats. This will reduce the pressure rise and therefore the height of the standpipe necessary and will at the same time keep the voltage of the generators in perfect control. After the load is again picked up, the switches connecting the rheostats can be opened from the switchboard, the rheostats being left in the water at all times. This scheme is of course applicable only under certain load conditions.

136 Equalizing reservoirs are usually provided with an overflow or spill-way, so that their maximum height need not exceed that of the forebay level.

137 From the foregoing it will be seen that the location of the standpipe or regulating reservoir cannot always be as desired, and the solution of the problem of pressure variation is in many cases only partially solved by them. It is true that an entirely artificial reservoir or a standpipe could be located almost at will, but the cost would usually prove excessive, and, unless a natural site for either is available, their distance from the power house will reduce itself largely to a question of cost, and the cost of increased flywheel effect must be balanced against the cost of closer proximity of standpipe to turbine, to produce the desired regulation.

138 As already stated in our discussion of the pressure regulator, the pressure drop is always less than the pressure rise, so that it is necessary only to bring the standpipe near enough to prevent excessive pressure drop, disregarding the pressure rise and providing for it by means of a pressure regulator.

139 The capacity of a standpipe must be the same regardless of the distance it is located from the turbine, provided the other conditions, such as maximum change of load to be provided for and regulating time are the same. If a greater regulating time is allowed on account of having a longer penstock, the capacity of the standpipe could theoretically be reduced slightly, but this should not be done in practice, and the formulae given therefore hold good for any conditions.

140 In a plant with long penstocks, where it is impossible to install a standpipe, and where it is practically out of the question to increase the size of the penstocks on account of excessive cost or otherwise, it will often be found impracticable to provide sufficient flywheel effect to obtain satisfactory regulation.

SYNCHRONOUS BYPASS

141 If this is the case in connection with reaction turbines, a synchronous bypass must be provided which should be exactly what the name implies; that is, it should discharge that part of the full load flow of the water which is not passing through the turbine at any given time. If the flow of the water through the turbine is changed in volume, the change in flow through the bypass should correspond.

142 It is very difficult to design a bypass that will do this, since the discharge through the turbine gates is not proportional to the governor stroke, from which the bypass must be operated, and furthermore the coefficient of discharge of the bypass cannot be kept constant during its full range of opening. Due to these causes and the insensitiveness of the governor, the pressure variations both ways may be quite considerable with the synchronous bypass and should be considered in computing the speed regulation. They may be as high as 25%, but the writer's experience shows that they can be kept as low as 10% for both opening and closing gates. The bypass should always be brought as near as possible to the turbine gates and in line with the flow of water into them.

DEFLECTING NOZZLE

143 In the case of impulse turbines, the synchronous bypass may also be used, but the deflecting nozzle is more generally used in practice, as it has several important advantages. With the latter the flow of water is not interfered with, but the stream is partially or wholly

deflected from the buckets, maintaining practically constant pressure, and varying the active volume only. The problem therefore reduces itself into one identical with that of a turbine in open flume, or without pressure variations, and the regulation is subject only to the fly-wheel effect.

144 Both of the devices mentioned above, and which are too well known to require detailed description, are extremely wasteful, and although numerous modifications have been made to reduce their wastefulness, such devices usually interfere with automatic regulation and the lessening of their wastefulness is one of degree only. In places where fixed quantities of water must be passed, regardless of the load on the plant, such as in plants where no storage whatever is available, or where irrigation or other laws require it, these two methods of regulation may prove the proper solution.

145 No solution of a problem in speed regulation is commercially correct, unless accompanied by an analysis of the probable load curve of the power plant to be regulated. It is evidently useless to provide against something which will never occur. Thus, if a plant consists of a number of large units, the greatest load change to be considered should be carefully gone into. This decided, it should be known over how many units the load change must be distributed; in other words, what will be the least number of units running in parallel on one circuit. In a large plant it is very seldom necessary to consider a total load change, (100% change of load) whereas in small plants this may frequently occur, especially when only one unit is running

AIR CHAMBER

146 Upon first consideration, it appears that an air chamber would be an ideal means to provide against extreme pressure variations. The necessary volume of such a device can be computed from the following formula:

$$V = \frac{T \times v}{\frac{(D\,H)}{H}} \qquad [26]$$

where

V = volume of air chamber in cu. ft.

T = accelerating time $= \frac{Lv}{gH}$

v = velocity in penstock in ft. per sec.

$\frac{(DH)}{H}$ = permissible pressure variation

147 It will be usually found that extremely large and therefore expensive air chambers are required. However, leaving the cost out of consideration, there is a constant danger connected with this device, since the water absorbs the air, so that it may not only be of no use, but may greatly increase the pressure variations. Although such modifications of the simple air chamber as automatically operated air compressors and check valves at the penstock connection have been suggested, they should be used only as a last resort.

TABLE 1 CHARACTERISTICS OF STANDARD REACTION TURBINE RUNNERS

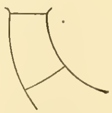
Specific speed $k = \frac{\text{r.p.m.}}{H}\sqrt{\frac{\text{h.p.}}{\sqrt{H}}}$ = speed in r.p.m. of a turbine runner diminished in all dimensions to such an extent as to develop 1 h.p. when working under the head $H = 1$ ft.

h.p._1 = horsepower per 1-ft. head = $\frac{\text{h.p. for any head}}{H \times \sqrt{H}}$. Power varies as $\sqrt{H^3}$. Therefore h.p. for any head $= \text{h.p.}_1 \times H \times \sqrt{H}$.

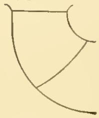
r.p.m._1 = revolutions per 1-ft. head = $\frac{\text{r.p.m.}}{\sqrt{H}}$. Speed varies as $\sqrt{H}$. Therefore r.p.m. $= \text{r.p.m.}_1 \times \sqrt{H}$.

Q_1 = quantity per 1-ft. head = $\frac{Q}{\sqrt{H}}$. Discharge varies as $\sqrt{H}$. Therefore $Q = Q_1 \times \sqrt{H}$

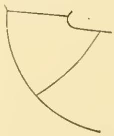
Type A



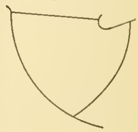
Type B



Type C



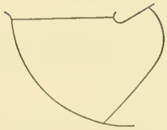
Type D



	Type A			Type B			Type C			Type D		
	Specific speed $k = 13.55$			$k = 20.3$			$k = 29.4$			$k = 40.7$		
	Peripheral speed $u_1 = 0.585$			$u_1 = 0.625$			$u_1 = 0.665$			$u_1 = 0.70$		
Diam.	r.p.m._1	h.p._1	Q_1	r.p.m._1	h.p._1	Q_1	r.p.m._1	h.p._1	Q_1	r.p.m._1	h.p._1	Q_1
15	71.7	0.0358	0.38	76.7	0.0705	0.791	81.5	0.130	1.35	85.6	0.226	2.38
18	59.8	0.0514	0.55	64.0	0.105	1.10	68.0	0.187	1.95	71.5	0.324	3.42
21	51.2	0.0705	0.75	54.7	0.1385	1.45	58.2	0.225	2.34	61.3	0.442	4.64
24	44.75	0.0915	0.975	47.8	0.182	1.91	51.0	0.333	3.46	53.55	0.577	6.08
27	39.8	0.116	1.235	42.5	0.229	2.41	45.2	0.423	4.40	47.6	0.731	7.70
30	35.8	0.1425	1.52	38.25	0.284	2.982	40.2	0.520	5.40	42.8	0.902	9.47
34	31.65	0.184	1.96	33.8	0.363	3.82	36.0	0.668	6.95	37.8	1.158	12.20
38	28.25	0.23	2.442	30.2	0.453	4.78	32.2	0.835	8.68	33.8	1.444	15.20
42	25.65	0.28	2.98	27.4	0.551	5.80	29.1	1.016	10.55	30.6	1.765	18.50
46	23.40	0.336	3.58	25.0	0.665	7.00	26.6	1.225	12.78	27.9	2.120	22.3
50	21.50	0.398	4.24	22.9	0.790	8.40	24.4	1.450	15.10	25.65	2.50	26.3
55	19.56	0.48	5.12	20.9	0.950	10.00	22.25	1.745	18.10	23.30	3.04	32.0
60	17.90	0.573	6.10	19.1	1.130	11.90	20.4	2.08	21.60	21.40	3.61	38.0
65	16.55	0.672	7.15	17.65	1.330	14.00	18.8	2.44	25.40	19.80	4.22	44.2
70	15.40	0.785	8.35	16.40	1.535	16.15	17.5	2.82	29.40	18.35	4.90	51.5

TABLE 1—Continued

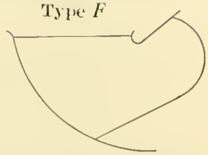
Type E



$k = 49.7 - 62.8$

$u_1 = 0.72 - 0.78$

Type F



$k = 70.0 - 83.85$

$u_1 = 0.835 - 0.89$

Diam.	r.p.m.₁	h.p.₁	Q_1	r.p.m.₁	h.p.₁	Q_1	Diam.
14	94.6	0.277	2.95	110.9	0.410	4.53	14
16	83.6	0.367	3.90	97.0	0.541	5.96	16
18	74.3	0.471	5.02	86.8	0.704	7.77	18
20	67.0	0.597	6.37	77.0	0.912	10.01	20
22	61.0	0.731	7.80	69.7	1.133	12.55	22
24	56.0	0.883	9.42	64.3	1.375	15.20	24
26	52.0	1.055	11.20	59.5	1.623	17.95	26
28	48.1	1.243	13.25	55.3	1.930	21.30	28
30	45.5	1.436	15.30	52.0	2.20	24.30	30
32	42.7	1.65	17.55	49.1	2.555	28.25	32
34	40.3	1.89	20.10	46.6	2.825	31.20	34
36	38.2	2.15	22.80	44.1	3.14	34.75	36
38	36.2	2.42	25.70	41.9	3.52	38.90	38
40	34.5	2.75	29.3	39.8	3.93	43.40	40
42.5	32.5	3.09	33.0	37.5	4.33	47.80	42.5
45	30.8	3.53	37.6	35.8	4.92	54.25	45
47.5	28.8	4.01	42.65	34.0	5.66	62.60	47.5
50	27.8	4.45	47.4	32.3	6.13	67.80	50
52.5	26.6	4.95	52.7	30.8	6.75	74.60	52.5
55	25.45	5.52	58.8	29.9	7.50	82.75	55
57.5	24.3	6.10	65.0	28.2	8.16	90.00	57.5
60	23.4	6.80	72.4	27.05	8.94	98.70	60
64	22.1	7.63	81.25	25.60	10.05	111.0	64
68	20.9	8.57	91.3	24.20	11.34	125.0	68
72	19.8	9.58	102.0	22.58	13.07	144.0	72
76	18.8	10.92	116.0	21.50	14.52	161.0	76
80	17.9	12.30	131.0	20.36	16.29	180.0	80
84	....	....	.....	19.50	17.88	197.0	84
88	....	....	.....	18.60	20.4	225.0	88
92	....	....	.....	17.75	22.0	243.0	92
96	....	....	.....	16.85	24.48	270.0	96
100	....	....	.....	16.30	26.46	293.0	100

TABLE 2 PRESSURE VARIATIONS FOR OPENING OR CLOSING TIME OF 1 SEC.

+ Sign Indicates Pressure Rise; — Sign Pressure Drop. To Get Results in Per Cent Multiply Tabular Values by 100.

$\frac{L}{H}$		Velocities in Penstock in Ft. per Sec.														
		1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
1	+	0.032	0.064	0.098	0.132	0.169	0.205	0.243	0.283	0.322	0.372	0.450	0.545	0.640	0.740	0.850
	−	0.032	0.060	0.090	0.116	0.144	0.172	0.195	0.220	0.244	0.274	0.311	0.351	0.390	0.425	0.460
1.5	+	0.047	0.096	0.150	0.205	0.260	0.322	0.386	0.446	0.520	0.587	0.74	0.90	1.08	1.26	1.46
	−	0.045	0.088	0.131	0.169	0.206	0.244	0.279	0.309	0.342	0.391	0.425	0.475	0.520	0.560	0.595
2	+	0.065	0.132	0.207	0.280	0.360	0.450	0.543	0.638	0.740	0.840	1.07	1.33	1.62	1.91	2.22
	−	0.060	0.116	0.171	0.219	0.265	0.311	0.351	0.388	0.425	0.456	0.515	0.575	0.618	0.655	0.69
2.5	+	0.081	0.168	0.270	0.361	0.470	0.590	0.716	0.850	0.990	1.14	1.46	1.84	2.25	2.69	3.19
	−	0.075	0.143	0.215	0.265	0.320	0.370	0.415	0.460	0.497	0.534	0.593	0.642	0.691	0.727	0.758
3	+	0.098	0.205	0.322	0.450	0.588	0.740	0.905	1.08	1.26	1.47	1.91	2.42	2.99	3.60	4.31
	−	0.090	0.169	0.244	0.310	0.368	0.425	0.471	0.518	0.560	0.598	0.655	0.705	0.748	0.780	0.815
3.5	+	0.116	0.243	0.385	0.544	0.708	0.90	1.11	1.33	1.55	1.86	2.41	3.06	3.81	4.66	5.60
	−	0.104	0.193	0.276	0.550	0.415	0.475	0.528	0.580	0.612	0.655	0.707	0.752	0.791	0.822	0.85
4	+	0.132	0.284	0.453	0.635	0.840	1.07	1.33	1.62	1.91	2.26	2.97	3.82	4.80	5.86	7.10
	−	0.116	0.220	0.312	0.386	0.456	0.522	0.572	0.615	0.655	0.693	0.752	0.791	0.82	0.850	0.89
4.5	+	0.150	0.323	0.520	0.736	0.985	1.26	1.57	1.910	2.28	2.69	3.60	4.66	5.87	7.22	8.72
	−	0.130	0.244	0.343	0.425	0.495	0.556	0.612	0.655	0.692	0.728	0.780	0.822	0.85	0.882	0.90
5	+	0.168	0.364	0.592	0.848	1.130	1.46	1.86	2.24	2.69	3.19	4.26	5.60	7.12	8.75	10.6
	−	0.144	0.266	0.371	0.460	0.531	0.595	0.654	0.693	0.730	0.758	0.810	0.840	0.885	0.910	0.915
6	+	0.206	0.450	0.739	1.08	1.46	1.90	2.44	2.99	3.60	4.31	5.88	7.75	9.90	12.2	14.9
	−	0.171	0.310	0.425	0.515	0.590	0.652	0.712	0.758	0.782	0.812	0.862	0.892	0.917	0.94	0.94
7	+	0.243	0.540	0.902	1.32	1.82	2.40	3.06	3.82	4.66	5.60	7.70	10.2	13.0	15.3	19.9
	−	0.195	0.350	0.478	0.570	0.640	0.712	0.746	0.792	0.822	0.84	0.89	0.92	0.93	0.96	0.96
8	+	0.285	0.640	1.08	1.62	2.24	2.97	3.84	4.81	5.88	7.12	9.80	13.1	16.8	21.0	25.8
	−	0.221	0.390	0.516	0.620	0.695	0.753	0.790	0.83	0.861	0.89	0.925	0.94	0.95	0.975	0.975
9	+	0.322	0.740	1.27	1.92	2.66	3.60	4.72	5.87	7.22	8.75	12.2	16.3	21.1	26.5	32.3
	−	0.244	0.425	0.560	0.660	0.730	0.780	0.82	0.86	0.880	0.92	0.94	0.96	0.97	0.985	0.99
10	+	0.375	0.850	1.47	2.23	3.16	4.27	5.60	7.10	8.75	10.6	14.8	19.9	25.7	32.3	39.6
	−	0.275	0.460	0.595	0.695	0.760	0.81	0.84	0.886	0.895	0.95	0.96	0.98	0.99	1.00	1.00

15	+	0.595	1.460	2.70	4.26	6.28	8.73	11.7	14.8	18.6	22.9	32.2	43.3	57.1	71.5	87.5
	−	0.374	0.595	0.735	0.810	0.86	0.898	0.93	0.945	0.95	0.98	0.98	1.00	1.00	1.00	1.00
20	+	0.850	2.22	4.31	7.02	10.6	14.8	19.9	25.7	32.2	39.8	56.5	76.5	100.0	126.0	155.0
	−	0.461	0.69	0.812	0.87	0.915	0.93	0.94	0.97	0.98	1.00	1.00	1.00	1.00	1.00	1.00
25	+	1.14	3.20	6.35	10.5	16.0	22.6	30.6	39.5	50.0	61.7	88.0	119.0	156.0	197.0	244.0
	−	0.535	0.765	0.868	0.915	0.96	0.955	0.96	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30	+	1.47	4.30	8.75	14.8	22.6	32.1	44.0	56.6	71.5	88.2	126.0	171.0	225.0	283.0	350.0
	−	0.60	0.81	0.91	0.93	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	+	2.25	7.10	15.0	25.5	39.4	56.4	77.2	100.0	127.0	158.0	222.0	3.04	399.0	504.0	621.0
	−	0.695	0.888	0.955	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	+	3.21	10.6	22.9	39.7	61.0	87.5	120.0	155.0	198.0	244.0	346.0	475.0	622.0	785.0	970.0
	−	0.772	0.92	0.982	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
60	+	4.31	14.9	32.4	57.00	87.5	105.0	172.0	222.0	282.0	350.0	503.0	688.0	898.0	1130.0	1400.0
	−	0.812	0.955	0.985	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	+	7.12	25.8	57.0	100.0	155.0	223.0	306.0	396.0	505.0	620.0	890.0	1215.0	1585.0	2000.0	2480.0
	−	0.90	0.98	0.995	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100	+	10.60	39.6	88.5	155.0	240.00	347.0	476.0	625.0	785.0	967.0	1395.0	1900.0	2490.0	3140.0	3870.00
	−	0.915	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 3 PRESSURE VARIATIONS FOR OPENING OR CLOSING TIME OF 2 SEC.

+ Sign Indicates Pressure Rise; − Sign Pressure Drop. To Get Results in Per Cent Multiply Tabular Values by 100.

L / H		Velocities in Penstock in Ft. per Sec.														
		1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
1	+	0.016	0.032	0.049	0.064	0.081	0.098	0.116	0.132	0.150	0.169	0.205	0.243	0.283	0.322	0.372
	−	0.016	0.032	0.047	0.060	0.075	0.090	0.104	0.116	0.130	0.144	0.172	0.195	0.220	0.244	0.274
1.5	+	0.024	0.047	0.073	0.096	0.123	0.150	0.165	0.205	0.234	0.260	0.322	0.386	0.446	0.520	0.587
	−	0.024	0.045	0.068	0.088	0.109	0.131	0.142	0.169	0.189	0.206	0.244	0.279	0.309	0.342	0.391
2	+	0.033	0.065	0.098	0.132	0.169	0.207	0.243	0.280	0.322	0.360	0.450	0.543	0.638	0.740	0.840
	−	0.032	0.060	0.090	0.116	0.146	0.171	0.195	0.219	0.244	0.265	0.311	0.351	0.388	0.425	0.456
2.5	+	0.041	0.081	0.123	0.168	0.214	0.270	0.310	0.361	0.416	0.470	0.590	0.716	0.850	0.990	1.140
	−	0.039	0.075	0.109	0.143	0.176	0.215	0.237	0.265	0.294	0.320	0.370	0.415	0.460	0.497	0.534
3	+	0.049	0.098	0.150	0.205	0.262	0.322	0.386	0.450	0.520	0.588	0.740	0.905	1.080	1.260	1.470
	−	0.047	0.090	0.130	0.169	0.209	0.244	0.277	0.310	0.342	0.368	0.425	0.471	0.518	0.560	0.598
3.5	+	0.058	0.116	0.178	0.243	0.311	0.385	0.460	0.544	0.625	0.708	0.90	1.110	1.330	1.550	1.860
	−	0.054	0.104	0.151	0.195	0.239	0.276	0.315	0.350	0.385	0.415	0.475	0.528	0.580	0.612	0.655
4	+	0.066	0.132	0.205	0.284	0.364	0.453	0.549	0.635	0.740	0.840	1.070	1.330	1.620	1.910	2.260
	−	0.062	0.116	0.171	0.222	0.266	0.312	0.350	0.386	0.426	0.456	0.522	0.572	0.615	0.655	0.693
4.5	+	0.073	0.150	0.233	0.323	0.416	0.520	0.625	0.736	0.860	0.985	1.260	1.570	1.910	2.280	2.690
	−	0.068	0.130	0.189	0.244	0.294	0.543	0.385	0.425	0.463	0.495	0.556	0.612	0.655	0.692	0.728
5	+	0.081	0.168	0.261	0.364	0.471	0.592	0.716	0.849	0.988	1.130	1.460	1.860	2.240	2.690	3.190
	−	0.075	0.144	0.209	0.266	0.320	0.371	0.415	0.460	0.496	0.531	0.595	0.654	0.693	0.730	0.758
6	+	0.098	0.206	0.322	0.450	0.590	0.739	0.90	1.080	1.260	1.460	1.90	2.44	2.990	3.60	4.310
	−	0.090	0.171	0.244	0.310	0.360	0.425	0.475	0.515	0.558	0.590	0.625	0.712	0.758	0.782	0.812
7	+	0.116	0.243	0.385	0.540	0.715	0.902	1.110	1.320	1.58	1.82	2.40	3.06	3.82	4.660	5.60
	−	0.104	0.195	0.277	0.350	0.420	0.478	0.525	0.570	0.612	0.640	0.712	0.746	0.792	0.822	0 840
8	+	0.134	0.285	0.450	0.640	0.848	1.080	1.33	1.620	1.910	2.24	2.97	3.84	4.81	5.88	7.12
	−	0.118	0.221	0.312	0.390	0.460	0.516	0.570	0.620	0.655	0.695	0.753	0.790	0.830	0.861	0.890
9	+	0.150	0.322	0.52	0.74	0.99	1.27	1.57	1.92	2.28	2.66	3.60	4.72	5.87	7.22	8.75
	−	0.130	0.244	0.342	0.425	0.496	0.560	0.612	0.660	0.693	0.730	0.780	0.820	0.860	0.880	0.920
10	+	0.169	0.375	0.594	0.850	1.140	1.470	1.840	2.230	2.69	3.160	4.27	5.60	7.10	8.75	10.60
	−	0 144	0.275	0.372	0.460	0.533	0.595	0.650	0.695	0.730	0.760	0.810	0.840	0.886	0.895	0.950

15	+	0.264	0.595	0.99	1.46	2.02	2.70	3.130	4.260	5.25	6.280	8.73	11.70	14.80	18.60	22.90
	−	0.210	0.374	0.497	0.595	0.665	0.735	0.755	0.810	0.840	0.860	0.898	0.930	0.945	0.950	0.980
20	+	0.361	0.850	1.46	2.22	3.16	4.31	5.60	7.020	8.750	10.60	14.80	19.90	25.70	32.20	39.80
	−	0.265	0.461	0.60	0.69	0.76	0.812	0.84	0.87	0.895	0.915	0.930	0.940	0.970	0.980	1.00
25	+	0.473	1.140	2.04	3.20	4.58	6.35	8.30	10.50	13.20	16.00	22.60	30.60	39.50	50.00	61.70
	−	0.322	0.535	0.672	0.765	0.816	0.868	0.898	0.915	0.928	0.960	0.960	0.970	0.990	1.00	1.00
30	+	0.59	1.47	2.69	4.30	6.30	8.75	11.70	14.80	18.60	22.6	32.10	44.0	56.60	71.50	88.2
	−	0.371	0.60	0.73	0.81	0.853	0.910	0.950	0.955	0.960	0.99	0.99	1.00	1.00	1.00	1.00
40	+	0.852	2.20	4.32	7.10	10.70	15.00	19.90	25.50	32.2	39.40	56.40	77.2	100.0	127.0	158.0
	−	0.456	0.695	0.813	0.88	0.92	0.955	0.970	0.97	0.98	1.00	1.00	1.00	1.00	1.00	1.00
50	+	1.14	3.21	6.32	10.6	16.00	22.90	30.80	39.7	50.0	61.00	87.5	120.0	155.0	198.0	244.0
	−	0.535	0.772	0.877	0.92	0.952	0.982	0.990	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
60	+	1.46	4.31	8.50	14.9	22.60	32.40	43.50	57.00	71.5	87.5	125.0	172.0	222.0	282.0	350.0
	−	0.590	0.812	0.920	0.953	0.980	0.985	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	+	2.260	7.120	14.90	25.8	39.60	57.00	77.2	100.0	126.0	155.0	223.0	306.0	396.0	505.0	620.0
	−	0.695	0.90	0.95	0.98	0.995	0.995	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100	+	3.19	10.60	22.90	39.6	61.80	88.5	120.0	155.0	197.0	240.0	347.0	476.0	625.0	785.0	967.0
	−	0.758	0.915	0.985	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 4 PRESSURE VARIATIONS FOR OPENING OR CLOSING TIME OF 3 SEC.

+ Sign Indicates Pressure Rise; — Sign Pressure Drop. To Get Results in Per Cent Multiply Tabular Values by 100.

L/H		Velocities in Penstock in Ft. per Sec.														
		1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
1	+	0.010	0.022	0.032	0.043	0.053	0.064	0.077	0.087	0.098	0.109	0.132	0.158	0.182	0.205	0.231
	—	0.010	0.020	0.032	0.041	0.051	0.060	0.071	0.081	0.090	0.099	0.116	0.136	0.154	0.172	0.187
1.5	+	0.016	0.032	0.047	0.064	0.081	0.096	0.116	0.132	0.150	0.168	0.205	0.243	0.282	0.322	0.363
	—	0.015	0.031	0.045	0.060	0.075	0.088	0.104	0.116	0.131	0.143	0.169	0.195	0.220	0.244	0.266
2	+	0.022	0.043	0.065	0.087	0.109	0.132	0.158	0.182	0.207	0.231	0.280	0.337	0.392	0.450	0.515
	—	0.020	0.041	0.060	0.081	0.098	0.116	0.136	0.154	0.171	0.187	0.219	0.252	0.282	0.311	0.337
2.5	+	0.026	0.053	0.081	0.109	0.138	0.168	0.198	0.231	0.270	0.296	0.361	0.435	0.515	0.590	0.670
	—	0.025	0.051	0.075	0.099	0.122	0.143	0.166	0.187	0.215	0.229	0.265	0.304	0.337	0.370	0.400
3	+	0.032	0.064	0.098	0.132	0.168	0.205	0.243	0.282	0.322	0.363	0.450	0.540	0.639	0.740	0.844
	—	0.031	0.060	0.090	0.116	0.144	0.169	0.195	0.220	0.244	0.266	0.310	0.350	0.389	0.425	0.459
3.5	+	0.037	0.077	0.116	0.158	0.198	0.243	0.287	0.337	0.385	0.435	0.544	0.657	0.775	0.900	1.040
	—	0.036	0.071	0.104	0.136	0.166	0.193	0.224	0.252	0.276	0.304	0.350	0.395	0.438	0.475	0.520
4	+	0.043	0.087	0.132	0.182	0.231	0.284	0.337	0.392	0.453	0.515	0.635	0.780	0.922	1.070	1.240
	—	0.041	0.081	0.118	0.154	0.187	0.220	0.252	0.282	0.312	0.337	0.386	0.439	0.482	0.522	0.560
4.5	+	0.047	0.098	0.150	0.206	0.270	0.323	0.336	0.454	0.520	0.595	0.736	0.902	1.080	1.260	1.470
	—	0.045	0.090	0.130	0.171	0.215	0.244	0.279	0.311	0.343	0.374	0.425	0.478	0.515	0.556	0.600
5	+	0.053	0.109	0.168	0.231	0.296	0.364	0.435	0.515	0.592	0.670	0.848	1.040	1.240	1.460	1.700
	—	0.051	0.098	0.144	0.187	0.229	0.266	0.304	0.337	0.371	0.400	0.460	0.510	0.560	0.595	0.617
6	+	0.064	0.132	0.206	0.282	0.375	0.450	0.540	0.639	0.739	0.844	1.080	1.330	1.620	1.900	2.220
	—	0.060	0.116	0.171	0.220	0.275	0.310	0.350	0.389	0.425	0.459	0.515	0.572	0.620	0.652	0.690
7	+	0.077	0.159	0.243	0.337	0.435	0.540	0.657	0.775	0.902	1.040	1.320	1.670	2.02	2.40	2.86
	—	0.071	0.138	0.195	0.252	0.304	0.350	0.395	0.438	0.478	0.509	0.570	0.628	0.665	0.712	0.743
8	+	0.087	0.181	0.285	0.392	0.511	0.640	0.775	0.922	1.080	1.240	1.620	2.020	2.50	2.97	3.54
	—	0.081	0.152	0.221	0.282	0.336	0.390	0.438	0.482	0.516	0.560	0.620	0.665	0.718	0.753	0.780
9	+	0.098	0.205	0.322	0.454	0.595	0.740	0.905	1.080	1.270	1.470	1.920	2.40	2.97	3.60	4.29
	—	0.090	0.169	0.244	0.311	0.374	0.425	0.471	0.515	0.560	0.600	0.660	0.712	0.753	0.780	0.810
10	+	0.109	0.231	0.375	0.515	0.670	0.850	1.040	1.240	1.470	1.700	2.230	2.860	3.54	4.27	5.15
	—	0.099	0.187	0.275	0.337	0.400	0.460	0.510	0.560	0.595	0.617	0.695	0.735	0.780	0.810	0.942

15	+	0.168	0.363	0.595	0.844	1.140	1.460	1.860	2.200	2.700	3.210	4.260	5.60	7.10	8.73	10.60
	−	0.143	0.266	0.374	0.459	0.525	0.595	0.654	0.690	0.735	0.772	0.810	0.840	0.887	0.898	0.915
20	+	0.231	0.511	0.850	1.240	1.700	2.22	2.86	3.540	4.310	5.150	7.02	9.40	12.00	14.80	18.20
	−	0.187	0.336	0.461	0.560	0.617	0.690	0.735	0.780	0.812	0.842	0.870	0.890	0.947	0.950	0.980
25	+	0.296	0.670	0.140	1.710	2.380	3.200	4.120	5.150	6.350	7.650	10.50	14.20	18.20	22.60	28.00
	−	0.229	0.400	0.535	0.629	0.700	0.765	0.800	0.842	0.868	0.885	0.915	0.940	0.98	0.99	1 00
30	+	0.363	0.843	1.470	2.220	3.210	4.300	5.60	7.100	8.750	10.60	14.80	19.90	25.50	32.10	39.60
	−	0.266	0.462	0.600	0.690	0.772	0.81	0.840	0.887	0.910	0.915	0.930	0.98	1.00	1.00	1.00
40	+	0.515	1.240	2.250	3.540	5.120	7.100	9.40	12.00	15.00	18.20	25.50	35.30	45.00	56.40	70.00
	−	0.337	0.552	0.695	0.78	0.840	0.888	0.890	0.947	0.955	0.980	0.980	1.00	1.00	1.00	1.00
50	+	0.67	1.70	3.21	5.15	7.65	10.60	14.20	18.20	22.90	28.00	39.70	54.00	70.00	87.50	109.0
	−	0.40	0.617	0.772	0.842	0.885	0.92	0.94	0.98	0.982	0.990	1.00	1.00	1.00	1.00	1.00
60	+	0.844	2.22	4.31	7.10	10.60	14.90	19.90	25.50	32.40	39.60	57.00	77.20	100.0	25.0	54.0
	−	0.459	0.689	0.812	0.887	0.915	0.955	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	+	1.240	3.53	7.12	12.00	18.20	25.80	35.30	45.0	57.0	70.0	100.0	137.0	178.0	223.0	276.0
	−	0.56	0.78	0.90	0.947	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100	+	1.70	5.120	10.60	18.20	28.00	39.6	54.00	70.00	88.50	109.0	155.0	212.0	282.0	347.0	430.0
	−	0.617	0.84	0.915	0.98	0.990	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 5 PRESSURE VARIATIONS FOR OPENING OR CLOSING TIME OF 4 SEC.

+ Sign Indicates Pressure Rise; — Sign Pressure Drop. To Get Results in Per Cent Multiply Tabular Values by 100.

$\frac{L}{H}$		Velocities in Penstock in Ft. per Sec.														
		1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
1	+	0.008	0.016	0.024	0.032	0.041	0.049	0.058	0.064	0.073	0.081	0.098	0.116	0.132	0.150	0.169
	−	0.008	0.016	0.023	0.032	0.039	0.047	0.054	0.060	0.068	0.075	0.090	0.104	0.116	0.130	0.144
1.5	+	0.012	0.024	0.036	0.047	0.060	0.073	0.087	0.096	0.109	0.123	0.150	0.165	0.205	0.234	0.260
	−	0.012	0.024	0.035	0.045	0.056	0.068	0.081	0.088	0.099	0.109	0.131	0.142	0.169	0.189	0.206
2	+	0.016	0.033	0.047	0.065	0.081	0.098	0.016	0.132	0.150	0.169	0.207	0.243	0.280	0.322	0.360
	−	0.015	0.032	0.045	0.060	0.075	0.090	0.104	0.116	0.130	0.146	0.171	0.195	0.219	0.244	0.265
2.5	+	0.020	0.041	0.060	0.081	0.102	0.123	0.145	0.168	0.189	0.214	0.270	0.310	0.361	0.416	0.470
	−	0.019	0.039	0.056	0.075	0.093	0.109	0.126	0.143	0.159	0.176	0.215	0.237	0.265	0.294	0 320
3	+	0.024	0.049	0.073	0.098	0.123	0.150	0.178	0.205	0.233	0.262	0.322	0.386	0.450	0.520	0 588
	−	0.023	0.047	0.068	0.090	0.109	0.130	0.151	0.169	0.189	0.209	0.244	0.277	0.310	0.342	0.368
3.5	+	0.028	0.058	0.087	0.116	0.145	0.178	0.211	0.243	0.279	0.311	0.285	0.460	0.544	0.625	0.708
	−	0.027	0.054	0.081	0.104	0.126	0.151	0.175	0.193	0.216	0.239	0.276	0.315	0.350	0.385	0.415
4	+	0.032	0.066	0.098	0.132	0.169	0.205	0.243	0.284	0.322	0.364	0.453	0.544	0.635	0.740	0.840
	−	0.031	0.062	0.090	0.116	0.146	0.171	0.195	0.220	0.244	0.266	0.312	0.350	0.386	0.426	0.456
4.5	+	0.036	0.073	0.109	0.150	0.189	0.233	0.279	0.323	0.367	0.416	0.520	0.625	0.736	0.860	0.985
	−	0.035	0.068	0.099	0.130	0.159	0.189	0.216	0.244	0.266	0.294	0.343	0.385	0.425	0.463	0.495
5	+	0.041	0.081	0.123	0.168	0.214	0.261	0.310	0.364	0.414	0.471	0.592	0.716	0.848	0.988	1.130
	−	0.030	0.075	0.109	0.144	0.176	0.209	0.236	0.266	0.289	0.320	3.71	0.415	0.460	0.496	0.531
6	+	0.047	0.098	0.150	0.206	0.262	0.322	0.385	0.450	0.520	0.590	0.739	0.900	1.080	1.260	1.460
	−	0.045	0.090	0.130	0.171	0.209	0.244	0.277	0.310	0.342	0.360	0.425	0.475	0.515	0.558	0.590
7	+	0.058	0.116	0.178	0.243	0.310	0.385	0.460	0.540	0.625	0.715	0.902	1.110	1.320	1.580	1.820
	−	0.054	0.104	0.151	0.195	0.236	0.277	0.315	0.350	0.385	0.420	0.478	0.525	0.570	0.612	0.640
8	+	0.064	0.134	0.206	0.285	0.264	0.450	0.540	0.640	0.740	0.848	1.080	1.330	1.620	1.910	2.240
	−	0.060	0.118	0.171	0.221	0.266	0.312	0.350	0.390	0.426	0.460	0.516	0.570	0.620	0.655	0.695
9	+	0.073	0.150	0.233	0.322	0.414	0.520	0.625	0.740	0.860	0.990	1.270	1.570	1.920	2.28	2.66
	−	0.068	0.130	0.189	0.244	0.289	0.342	0.385	0.425	0.463	0.496	0.560	0.612	0.660	0.693	0.730
10	+	0.081	0.169	0.262	0.375	0.471	0.594	0.715	0.850	0.990	1.140	1.470	1.840	2.23	2.69	3.160
	−	0.075	0.144	0.209	0.275	0.320	0.372	0.420	0.460	0.497	0.530	0.595	0.650	0.695	0.730	0.760

15	+	0.125	0.264	0.414	0.595	0.780	0.990	1.220	1.46	1.70	2.02	2.70	3.130	4.260	5.25	6.28
	−	0.109	0.210	0.289	0.374	0.439	0.497	0.547	0.595	0.617	0.665	0.735	0.755	0.810	0.840	0.86
20	+	0.160	0.361	0.590	0.850	1.140	1.460	1.84	2.22	2.690	3.16	4.31	5.60	7.02	8.75	10.60
	−	0.146	0.265	0.360	0.461	0.533	0.600	0.650	0.690	0.730	0.760	0.812	0.84	0.87	0.895	0.915
25	+	0.214	0.473	0.780	1.140	1.550	2.040	2.560	3.20	3.82	4.58	6.35	8.30	10.50	13.20	16.00
	−	0.176	0.322	0.439	0.535	0.670	0.672	0.713	0.765	0.791	0.816	0.868	0.898	0.915	0.928	0.96
30	+	0.262	0.590	0.990	1.470	2.04	2.69	3.450	4.30	5.25	6.300	8.75	11.70	14.80	18.60	22.60
	−	0.209	0.371	0.497	0.60	0.672	0.730	0.777	0.810	0.840	0.853	0.910	0.950	0.955	0.960	0.99
40	+	0.361	0.852	1.460	2.25	3.190	4.32	3.60	7.10	8.50	10.70	15.00	19.90	25.50	32.20	39.40
	−	0.266	0.456	0.60	0.695	0.758	0.813	0.84	0.888	0.920	0.920	0.955	0.970	0.98	0.990	1.00
50	+	0.471	1.140	2.040	3.210	4.58	6.32	8.30	10.60	13.20	16.00	22.80	30.80	39.70	50.00	61.00
	−	0.320	0.535	0.672	0.772	0.815	0.877	0.898	0.920	0.928	0.95	0.982	1.99	1.00	1.00	1.00
60	+	0.590	1.460	2.690	4.31	6.32	8.50	11.70	14.90	18.60	22.60	32.40	43.50	57.00	71.50	87.50
	−	0.360	0.590	0.730	0.812	0.877	0.920	0.950	0.960	0.945	0.980	0.985	1.00	1.00	1.00	1.00
80	+	0.848	2.260	4.320	7.120	0.60	19.90	19.90	25.8	32.20	39.60	57.0	77.20	100.0	126.0	155.0
	−	0.460	0.695	0.813	0.90	0.915	0.955	0.970	0.98	0.99	0.995	0.995	1.00	1.00	1.00	1.00
100	+	1.140	3.190	6.320	10.60	16.10	22.90	30.80	39.60	50.00	81.80	88.5	120.0	155.0	197.0	240.0
	−	0.533	0.758	0.877	0.915	0.950	0.985	0.990	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 6 PRESSURE VARIATIONS FOR OPENING OR CLOSING TIME OF 5 SEC.

+ Sign Indicates Pressure Rise; — Sign Pressure Drop. To Get Results in Per Cent Multiply Tabular Values by 100.

$\frac{L}{H}$		Velocities in Penstock in Ft. per Sec.														
		1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
1	+	0.006	0.013	0.019	0.024	0.032	0.038	0.045	0.051	0.058	0.064	0.078	0.091	0.104	0 118	0.132
	—	0.006	0.013	0.019	0.024	0.032	0.037	0.043	0.049	0.054	0.060	0.072	0.083	0.095	0.106	0.116
1.5	+	0.009	0.019	0.028	0.038	0.047	0.058	0.068	0.078	0.087	0.096	0.118	0.139	0.161	0.183	0.205
	—	0.009	0.019	0.028	0.037	0.045	0.054	0.064	0.072	0.081	0.088	0.106	0.112	0.138	0.154	0.169
2	+	0.013	0.024	0.038	0.051	0.065	0.078	0.091	0.104	0.118	0.132	0.161	0.189	0.221	0.250	0.280
	—	0.013	0.024	0.037	0.049	0.060	0.072	0.083	0.095	0.106	0.116	0.138	0.159	0.181	0.200	0.219
2.5	+	0.016	0.032	0.047	0.064	0.081	0.095	0.116	0.132	0.150	0.168	0.205	0.243	0.285	0.322	0.361
	—	0.016	0.032	0.045	0.060	0.075	0.090	0.104	0.116	0.130	0.143	0.169	0.195	0.221	0 244	0.265
3	+	0.019	0.038	0.058	0.078	0.098	0.118	0.139	0.161	0.183	0.205	0.250	0.299	0.346	0.399	0.450
	—	0.019	0.037	0.054	0.072	0.090	0.106	0.112	0.138	0.154	0.169	0.200	0.231	0.256	0.284	0.310
3.5	+	0.022	0.045	0.068	0.091	0.116	0.139	0.165	0.189	0.214	0.243	0.299	0.266	0.414	0.475	0.544
	—	0.022	0.043	0.064	0.083	0.104	0.112	0.141	0.159	0.176	0.193	0.231	0.262	0.289	0.323	0.350
4	+	0.024	0.051	0.078	0.104	0.132	0.161	0.189	0.221	0.250	0.284	0.346	0.414	0.485	0.561	0.635
	—	0.024	0.049	0.072	0.092	0.116	0.138	0.159	0.181	0.200	0.220	0.256	0.289	0.326	0.359	0.386
4.5	+	0.028	0.058	0.087	0.118	0.150	0.183	0.214	0.250	0.285	0.323	0.399	0.475	0.561	0.650	0.736
	—	0.028	0.054	0.081	0.106	0.130	0.154	0.175	0.200	0.222	0.244	0.284	0.327	0.259	0.396	0.425
5	+	0.032	0.64	0.098	0.132	0.168	0.205	0.243	0.285	0.322	0.364	0.446	0.540	0.640	0.740	0.848
	—	0.032	0.060	0.090	0.116	0.144	0.169	0.195	0.221	0.244	0.266	0.309	0.350	0.390	0 425	0.460
6	+	0.038	0.078	0.118	0.161	0.206	0.250	0.299	0.346	0.399	0.450	0.561	0.678	0.800	0.932	1.080
	—	0.037	0.072	0.106	0.138	0.171	0.200	0.231	0.256	0.284	0.310	0.359	0.405	0.445	0.483	0.515
7	+	0.045	0.091	0.139	0.189	0.243	0.299	0.366	0.414	0.475	0.540	0.678	0.822	0.988	1.150	1.320
	—	0.043	0.083	0.112	0.159	0.195	0.231	0.262	0.289	0.321	0.350	0.405	0.451	0.496	0.537	0.570
8	+	0.051	0.104	0.161	0.221	0.285	0.346	0.414	0.485	0.561	0.640	0.800	0.988	1.180	1.390	1.620
	—	0.049	0.095	0.138	0.181	0.221	0.256	0.289	0.326	0.359	0.390	0.445	0.496	0.542	0.580	0.620
9	+	0.058	0.118	0.183	0.250	0.322	0.399	0.475	0.561	0.650	0.740	0.932	1.150	1.390	1.630	1.920
	—	0.054	0.106	0.154	0.200	0.244	0.284	0.321	0.359	0.396	0.425	0.483	0.537	0.580	0.615	0.660
10	+	0.064	0.132	0.206	0.283	0.375	0.446	0.540	0.640	0.740	0.850	1.080	1.330	1.620	1.920	2.230
	—	0.060	0.116	0.171	0.220	0.275	0.309	0.350	0.390	0.425	0.460	0.516	0.572	0.618	0.669	0.695

15	+	0.098	0.206	0.322	0.446	0.595	0.740	0.902	1.080	1.270	1.460	1.920	2.410	2.990	3.530	4.260
	−	0.090	0.171	0.244	0.309	0.374	0.425	0.478	0.520	0.560	0.595	0.660	0.707	0.748	0.780	0.810
20	+	0.132	0.285	0.450	0.638	0.850	1.080	1.320	1.620	1.920	2.220	2.990	3.82	4.800	5.87	7.020
	−	0.116	0.221	0.310	0.388	0.461	0.516	0.570	0.618	0.660	0.690	0.748	0.791	0.820	0.860	0.870
25	+	0.168	0.375	0.595	0.850	1.140	1.470	1.820	2.250	2.660	3.200	4.310	5.600	7.120	8.750	10.50
	−	0.143	0.275	0.374	0.460	0.535	0.600	0.640	0.691	0.730	0.765	0.812	0.840	0.885	0.898	0.915
30	+	0.206	0.450	0.740	1.080	1.470	1.920	2.410	2.990	3.530	4.30	5.870	7.750	9.900	12.20	14.80
	−	0.171	0.310	0.425	0.518	0.600	0.660	0.707	0.748	0.780	0.810	0.860	0.892	0.917	0.940	0.950
40	+	0.285	0.640	1.080	1.620	2.250	2.990	3.820	4.800	5.870	7.100	9.900	13.10	16.80	21.00	25.50
	−	0.221	0.390	0.518	0.615	0.695	0.758	0.791	0.820	0.860	0.888	0.917	0.940	0.950	0.970	0.98
50	+	0.375	0.850	1.470	2.240	3.210	4.310	5.600	7.120	8.750	10.60	14.90	19.90	25.70	32.40	39.70
	−	0.275	0.461	0.600	0.693	0.772	0.812	0.840	0.885	0.898	0.920	0.950	0.98	0.965	0.980	1.00
60	+	0.540	1.320	1.920	2.990	4.310	5.870	7.750	9.900	12.20	14.90	21.00	28.40	36.60	46.20	57.00
	−	0.350	0.570	0.660	0.758	0.812	0.860	0.892	0.917	0.940	0.955	0.970	0.995	1.00	1.00	1.00
80	+	0.640	1.620	2.990	4.810	7.120	9.80	13.10	16.80	21.00	25.80	36.60	49.90	64.50	81.00	100.0
	−	0.390	0.620	0.758	0.83	0.900	0.925	0.940	0.940	0.970	0.98	0.985	1.00	1.00	1.00	1.00
100	+	0.850	2.25	4.310	7.100	10.60	14.90	19.90	25.70	32.4	39.50	56.70	76.5	100.0	126.0	155.0
	−	0.461	0.695	0.812	0.885	0.915	0.955	0.98	0.965	0.980	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 7 PRESSURE VARIATIONS FOR OPENING AND CLOSING TIME OF 6 SEC.

+ Sign Indicates Pressure Rise; − Sign Pressure Drop. To Get Results in Per Cent Multiply Tabular Values by 100.

$\frac{L}{H}$		Velocities in Penstock in Ft. per Sec.														
		1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
1	+	0.005	0.010	0.016	0.022	0.026	0.032	0.037	0.043	0.049	0.053	0.064	0.077	0.087	0.098	0.109
	−	0.005	0.010	0.016	0.020	0.025	0.032	0.036	0.041	0.047	0.051	0.060	0.071	0.081	0.090	0.99
1.5	+	0.008	0.016	0.024	0.032	0.041	0.047	0.058	0.064	0.073	0.081	0.096	0.116	0.132	0.150	0.168
	−	0.008	0.015	0.024	0.031	0.039	0.045	0.054	0.060	0.068	0.075	0.088	0.104	0.116	0.131	0.143
2	+	0.010	0.022	0.033	0.043	0.053	0.065	0.077	0.087	0.098	0.109	0.132	0.158	0.182	0.207	0.231
	−	0.010	0.020	0.032	0.041	0.051	0.060	0.071	0.081	0.090	0.098	0.116	0.136	0.154	0.171	0.187
2.5	+	0.013	0.026	0.041	0.053	0.068	0.081	0.098	0.109	0.123	0.138	0.168	0.198	0.231	0.270	0.296
	−	0.013	0.025	0.039	0.051	0.064	0.075	0.090	0.099	0.109	0.122	0.143	0.166	0.187	0.215	0.229
3	+	0.016	0.032	0.049	0.064	0.081	0.098	0.116	0.132	0.150	0.168	0.205	0.243	0.282	0.322	0.363
	−	0.016	0.031	0.047	0.060	0.075	0.090	0.104	0.116	0.130	0.144	0.169	0.195	0.220	0.244	0.266
3.5	+	0.018	0.037	0.058	0.077	0.098	0.116	0.139	0.158	0.178	0.198	0.243	0.287	0.337	0.385	0.435
	−	0 018	0.036	0.054	0.071	0.090	0.104	0.122	0.136	0.151	0.166	0.193	0.224	0.252	0.276	0.304
4	+	0.022	0.043	0.066	0.087	0.109	0.132	0.158	0.182	0.205	0.231	0.284	0.337	0.392	0.453	0.515
	−	0.020	0.041	0.062	0.081	0.099	0.116	0.136	0.154	0.171	0.187	0.220	0.252	0.282	0.312	0.337
4.5	+	0.024	0.047	0.073	0.098	0.123	0.150	0.181	0.206	0.233	0.270	0.323	0.383	0.454	0.520	0.595
	−	0.023	0.045	0.068	0.090	0.109	0.130	0.152	0.171	0.189	0.215	0.244	0.279	0.311	0.343	0.374
5	+	0.026	0.053	0.081	0.109	0.138	0.168	0.198	0.231	0.261	0.296	0.364	0.435	0.515	0.592	0.670
	−	0.025	0 051	0.075	0.098	0.122	0.144	0.166	0.187	0.209	0.229	0.266	0.304	0.337	0.371	0.400
6	+	0.032	0.064	0.098	0.132	0.168	0.206	0.243	0.282	0.322	0.375	0.450	0.540	0.639	0.739	0.844
	−	0.031	0.060	0.090	0.116	0.143	0.171	0.195	0.220	0.244	0.275	0.310	0.350	0.389	0.425	0.459
7	+	0.037	0 077	0.116	0.159	0.198	0.243	0.287	0.337	0.385	0.435	0.540	0.657	0.775	0.902	1.040
	−	0.036	0.071	0.104	0.138	0.166	0.195	0.224	0.252	0.277	0.304	0.350	0.395	0.438	0.478	0.509
8	+	0.043	0 087	0.134	0.181	0.231	0.285	0.337	0.392	0.450	0.511	0.640	0.775	0.922	1.080	1.240
	−	0.041	0.081	0.118	0.152	0.187	0.221	0.252	0.282	0.312	0.336	0 390	0.438	0.482	0.516	0.560
9	+	0.047	0.098	0.150	0.205	0.270	0.322	0.386	0.454	0.520	0.595	0.740	0.905	1 080	1.270	1.470
	−	0.045	0 090	0.130	0.169	0.215	0.244	0.279	0.311	0 342	0.374	0.425	0.471	0.515	0.560	0.600
10	+	0.053	0.109	0 169	0 231	0.296	0 375	0.435	0.515	0.594	0.670	0.850	0.104	1.210	1.470	1.700
	−	0 051	0 099	0 144	0 187	0 229	0 275	0.304	0 337	0 372	0.400	0.460	0 510	0.560	0.595	0.617

15	+	0.081	0.168	0.264	0.363	0.473	0.595	0.716	0.844	0.990	1.140	1.460	1.860	2.220	2.700	3.210
	−	0.075	0.143	0.210	0.266	0.322	0.374	0.415	0.459	0.497	0.525	0.595	0.654	0.690	0.735	0.772
20	+	0.109	0.231	0.361	0.511	0.672	0.850	1.040	1.240	1.460	1.700	2.220	2.86	3.540	4.310	5.150
	−	0.099	0.187	0.265	0.336	0.400	0.461	0.510	0.560	0.600	0.617	0.690	0.735	0.780	0.812	0.842
25	+	0.138	0.296	0.473	0.670	0.902	1.140	1.470	1.710	2.040	2.320	3.200	4.120	5.150	6.350	7.650
	−	0.122	0.229	0.322	0.400	0.478	0.535	0.600	0.629	0.672	0.700	0.765	0.80	0.842	0.868	0.885
30	+	0.168	0.363	0.590	0.843	1.140	1.470	1.860	2.220	2.690	3.210	4.300	5.600	7.100	8.78	10.60
	−	0.143	0.266	0.371	0.462	0.525	0.600	0.654	0.690	0.730	0.771	0.810	0.84	0.887	0.910	0.915
40	+	0.231	0.515	0.852	1.240	1.700	2.250	2.860	3.540	4.320	5.120	7.100	9.40	12.00	15.00	18.20
	−	0.187	0.337	0.456	0.552	0.617	0.695	0.735	0.780	0.813	0.840	0.888	0.89	0.947	0.955	0.980
50	+	0.296	0.670	1.140	1.700	2.380	3.210	4.120	5.150	6.320	7.650	10.60	14.20	18.20	22.90	28.00
	−	0.229	0.400	0.535	0.617	0.700	0.772	0.800	0.842	0.877	0.885	0.92	0.94	0.98	0.982	0.99
60	+	0.363	0.844	1.460	2.220	3.210	4.310	5.600	7.100	8.500	10.60	14.90	19.90	25.50	32.40	39.60
	−	0.266	0.459	0.590	0.689	0.772	0.812	0.840	0.887	0.920	0.915	0.955	0.98	1.00	1.00	1.00
80	+	0.515	1.240	2.260	3.530	5.120	7.120	7.220	12.00	14.90	18.20	25.8	35.3	45.00	57.00	70.00
	−	0.337	0.560	0.695	0.780	0.840	0.900	0.880	0.947	0.955	0.980	0.98	1.00	1.00	1.00	1.00
100	+	0.670	1.700	3.190	5.120	7.650	10.60	14.20	18.20	22.90	28.00	39.60	54.0	70.00	88.5	109.0
	−	0.400	0.617	0.758	0.840	0.885	0.915	0.940	0.980	0.985	0.990	1.00	1.00	1.00	1.00	1.00

TABLE 8 VELOCITY OF VIBRATIONS IN PENSTOCK

$$a = \sqrt{\frac{\frac{g}{y}}{\frac{1}{e} + \frac{1}{E} \cdot \frac{D}{d}}} = \frac{22{,}720}{\sqrt{23.5 + K \cdot \frac{D}{d}}}$$

Material of Penstock	Dia. of Penstock	Thickness of Penstock Walls in in.									
		$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	3	4	5
Steel Plate		3810	4160	4330	4400	4460	4530				
Cast iron	1 ft.	3380	3900	4100	4240	4300	4350	4430	4500		
Wood stave			2050	2400	2660	2860	3000	3250	3570	3800	
Steel plate		3310	3830	4040	4170	4270	4340				
Cast iron	2 ft.	2800	3370	3700	3900	4000	4100	4230	4380		
Wood stave				1810	2050	2230	2400	2650	3000	3250	
Steel plate		2950	3570	3820	4000	4100	4150				
Cast iron	3 ft.	2440	3050	3370	3600	3750	3900	4030	4220		
Wood stave				1520	1720	1880	2050	2300	2650	2900	
Steel plate		2700	3310	3600	3810	3960	4040				
Cast iron	4 ft.	2190	2800	3150	3390	3580	3700	3900	4100		
Wood stave				1330	1525	1680	1700	2050	2400	2650	
Steel plate		2530	3120	3450	3650	3830	3900				
Cast iron	5 ft.	2000	2600	2970	3210	3380	3520	3750	4000		
Wood stave					1380	1530	1660	1870	2200	2450	2650
Steel plate		2330	2950	3320	3600	3700	3850				
Cast iron	6 ft.		2450	2800	3050	3250	3400	3610	3900		
Wood stave					1260	1400	1520	1720	2050	2300	2510
Steel plate		2200	2810	3190	3410	3590	3710				
Cast iron	7 ft.			2650	2920	3120	3260	3500	3800		
Wood stave					1160	1300	1500	1600	1920	2160	2360
Steel plate		2100	2700	3060	3300	3470	3600				
Cast iron	8 ft.				2790	3000	3150	3380	3700		
Wood stave						1230	1330	1520	1800	2050	2230
Steel plate		2000	2600	2950	3200	3400	3570				
Cast iron	9 ft.				2650	2900	3050	3310	3600		
Wood stave						1170	1260	1450	1730	1960	2130
Steel plate		1920	2540	2880	3130	3310	3450				
Cast iron	10 ft.					2800	2980	3220	3520		
Wood stave						1120	1200	1380	1660	1880	2050
Steel plate		1770	2330	2700	3000	3150	3300				
Cast iron	12 ft.					2620	2790	3050	3380		
Wood stave						1000	1120	1260	1520	1720	1880
Steel plate		1660	2200	2560	2820	3000	3190				
Cast iron	14 ft.					2500	2650	2920	3260		
Wood stave						935	1040	1170	1490	1610	1770
Steel plate		1560	2100	2450	2710	2890	3060				
Cast iron	16 ft.					2400	2550	2800	3150		
Wood stave						875	965	1120	1330	1520	1670
Steel plate		1480	2000	2350	2600	2800	2950				
Cast iron	18 ft.						2450	2700	3050	3300	
Wood stave							900	1050	1260	1440	1590
Steel plate		1410	1920	2250	2520	2700	2870				
Cast iron	20 ft.						2330	2600	2960	3200	
Wood stave							870	990	1200	1380	1520

TOPICAL DISCUSSION ON THE PROBLEM OF SMOKE ABATEMENT

Introductory Discussion by D. T. Randall[1]

The abatement of smoke from bituminous coal is an engineering problem. In choosing a coal for use in a given plant, the following points should be considered:

a The amount and character of the volatile matter
b The amount of ash and its tendency to clinker
c Moisture
d Coking and caking qualities
e Size
f Amount to be burned in a given furnace
g The kind of furnace, hand-fired or automatic
h The draft available and its regulation
i The character of the load, steady or variable
j The ability of the firemen

Most of our boiler plants were originally built to burn anthracite coal, not many being properly equipped to burn the higher volatile bituminous coals. The burning of bituminous coal is more complicated for the reason that on charging the coal upon the fuel bed, the volatile gases begin to distill off as soon as the coal is heated to the required temperature. These gases are similar in character to unpurified illuminating gas and contain tar and heavy hydro-carbons and will produce smoke unless burned under very favorable conditions. If air could be admitted in sufficient quantities and in such a manner as to mix thoroughly with these gases as they are being distilled from the coal, they could be completely burned without smoke, provided the temperature of the furnace was sufficient to ignite them. The fixed carbon, or portion of the coal corresponding to coke, remains on the grate and is burned under the conditions described for coke or other fuels containing a low percentage of volatile matter.

[1] Presented at a Boston meeting (November 1910) of The American Society of Mechanical Engineers.

It appears from the experiments of Dr. Horace C. Porter, of the Bureau of Mines, that coals vary considerably in the character of their volatile matter, and that their percentage as determined by proximate analysis is not necessarily a correct measure of the difficulty which may be expected in preventing smoke. The volatile matter is composed in part of inert matter such as carbon dioxide and other combinations which do not burn, and the real volatile combustible matter may be much less than appears from the ordinary coal analysis. When coals of the same general character are considered, however, the volatile matter is a very fair measure of the difficulty which may be experienced in burning them without smoke. The difference between a coal containing 16 per cent volatile matter and another one containing 21 or 22 per cent is usually noticeable when a hand-fired furnace is used. A coal containing more than 25 per cent volatile matter is difficult to burn without smoke.

If the coal contained large quantities of ash the fires must be cleaned more frequently, and in addition it is difficult to secure an even distribution of air through the bed of fuel and ash. If the ash has a low fusing point and melts and sticks to the grate, air will be shut out over portions of the grate and the difficulty of preventing smoke will increase.

An increase in the moisture in the coal usually increases the difficulty of burning it without smoke. If a coal cokes in the fire and if the draft is such as to require the frequent breaking up of the fuel bed, the coal may give off more smoke at such times than when it is fired.

The size of the coal is of considerable importance for the reason that coals which are coarse must be carried at greater depth on the grates in order to prevent an excess of air, and the finer coals must be fired very carefully in order that they may not clog the air openings through the fuel bed and thus prevent a sufficient amount of air reaching the gases from the coal. Generally speaking, coal which is fine in size must be fired in smaller quantities than coals which are in the form of lumps and records of analyses show a wide variation in coals sold for power plant purposes, the volatile matter ranging from 16 to 35 per cent, the ash from $5\frac{1}{2}$ to 14 per cent, and the heating value from 13,000 to 14,600 B.t.u.

DESIGN OF FURNACES

It is evident that the design of a furnace for bituminous coal must be different from one for coke or anthracite coal. The most successful

designs provide for the admission of air to mingle with the liberated gases and also arrange some device which causes them to mix or burn before they leave the furnace, a time which probably does not exceed a second. Walls or arches are often provided which cause the gases to whirl and mix, and long or high combustion chambers are provided to allow time for the combustion to take place.

If it is found that an equipment is not satisfactory even when the most successful methods of firing are adopted, it will then in most cases be good business policy to invest in an improved type which will give practically complete combustion. There are many cases where the equipment is old and it would not be advisable to install new and expensive furnaces under an old boiler, or the power plant may be in a rented building, or for other reasons it may not be feasible to improve the furnaces. In such cases the solution must lie along the lines of choosing a coal which is best suited to the furnace which is installed. With such furnaces by mixing bituminous coal with an equal weight of anthracite screenings, quite satisfactory results may be obtained and without much difficulty from smoke. To burn such a mixture usually requires a little stronger draft than for bituminous coal alone.

In designing a combustion chamber, it is not necessarily a solution of the problem to provide a chamber of large capacity, unless it is of such a shape that the gases can be made to pass at a fairly uniform velocity over its entire cross section. A study of a great many plants seems to indicate that the distance through which the gases travel before they reach the heating surface is of more importance than the area of the passage through which they travel, for the reason that they have a tendency to travel in lines the shortest distance from the grate to the heating surface and thus to make a considerable portion of the combustion chambers merely dead spaces and inactive so far as combustion is concerned. In this connection it has been noted that the common, horizontal return tubular boiler has given very good results in comparison with other types of boilers, evidently because of the length of the travel of gases. Whenever a device is provided which tends to give a more intimate mixture of the air with the gases, it is possible to shorten the combustion chamber accordingly.

For each kind of coal and each furnace, there is apparently a range of capacity through which it is possible to operate without a serious production of smoke. At higher rates the efficiency decreases and black smoke is produced owing to a lack of furnace capacity to supply air and mix it with the gases.

The operation of firing a furnace by hand is of necessity an inter-

mittent one. Relatively large quantities of fuel must be placed on the fuel bed at one time. This fuel tends to retard the flow of air and at the same time the heat in the furnace tends to drive off the gases rapidly. Usually enough air cannot be supplied at this time and there is smoke for a minute or two after each firing, even when the stack is clear during the remainder of the time.

Hand-fired furnaces depending upon brick-work baffles, arches and piers are better than plain furnaces, and they generally decrease the smoke after the brick work is heated. Their capacity to absorb heat tends to counterbalance the gain from better combustion if a large amount of brick work is used and if the period of operation is short. A brick arch over the entire grate surface increases the rate of combustion for any given draft because it reflects heat back onto the fuel bed and assists in driving off the moisture and the volatile matter from the coal. This action may cause more volatile matter to escape than can be burned in the combustion chamber provided. In many cases more successful results in preventing smoke are obtained by omitting the arch above the grate and providing arches, piers, checkerwork, or similar construction at the bridge wall and a short distance behind it. Provisions for admitting extra air for a short period after each firing will often reduce the smoke to one-half the amount produced when only the regular supply is furnished through the grates and fuel bed. In general, furnaces based on such designs may be operated by skilled firemen with certain coals with good economy and with smoke only at short intervals after each firing or cleaning provided the rate of combustion is low.

Hand-fired furnaces properly equipped with steam jets and air admission may be operated with most coals so as to give but little black smoke except when cleaning the fires. The jet must be located so as to direct the current in the required direction to secure a rapid mixture of the gases from the coal with the air in the furnace. This often requires some experimenting. Steam jets require a large amount of steam to secure satisfactory results, but their use improves the combustion and if the methods of firing are improved when the apparatus is installed, the loss due to the use of steam may be fully or partially offset by the resulting economy. In connection with large combustion chambers or well-designed brick furnaces, fewer jets may be used or the pressure may be reduced to save steam.

In furnaces having the heating surface directly above the grate it is necessary to accomplish the admission of air by steam jets, unless sufficient air can be admitted uniformly through the grates.

A study of tests conducted at the Government fuel testing plant shows that with hand-fired furnaces the best results were obtained when the firing was done most frequently and with the smallest charges of coal. In general, coals which smoke badly give efficiencies from 3 to 6 per cent lower than coals which burn with but little smoke; also when the air supply is reduced and the furnace temperatures increased there is an increase in CO_2 and in CO which is always accompanied by smoke. In many cases there may be smoke and a considerable unaccounted-for loss when there is but little or no CO determined by the Orsat.

DESIGN OF STOKERS

These problems have led a number of inventors to design automatic stokers. With these the coal is fed in small quantities continuously in such a way as to be subjected to the heat gradually and at a comparatively low temperature and the gases are driven off mixed with air and completely burned in a combustion chamber before they reach the cooling surface of the boiler tubes. Many of these have been improved until they may be depended upon under normal conditions to burn almost any kind of bituminous coal successfully, when they are properly installed and operated. As a rule this installation included special settings and combustion chambers, depending upon the kind of boiler and of fuel to be used.

The chain grate stoker as ordinarily designed is very successful in burning high volatile and high ash coals. Under proper operation it is capable of burning such coal at high rates of combustion without smoke, and in some well-designed plants it is difficult to make these furnaces smoke even when they are improperly operated. These stokers are not adapted to burning low volatile coking coals.

Several makes of stokers on the market are designed to feed the coal from hoppers onto inclined grates, kept in motion by a driving mechanism. Some are so designed as to grind through a large portion of the ash which accumulates at the bottom of the grate. Whether this type of stoker is successful or not depends not only on its durability and resistance to the action of the heat, but also on its ability to feed the coal uniformly, heat it gradually and introduce a supply of air which will mix with and burn the gas before it has traveled far from the point at which it is liberated. Many stokers of this type are so installed and operated as to give good efficiency and smokeless combustion, but there are many others which are smoking badly.

Only within the last few years have the manufacturers of such equipment given serious consideration to the smoke problem and recognized that the stokers must be set in furnaces especially designed, with due regard to the kind of coal, boiler and service for which they are intended. It is a mistake to install these or any other stokers believing that they do not require as much or an even higher degree of skill than a hand-fired plant, provided good results are to be secured. There are two or three makes of under-feed stokers on the market. If they are so designed as to be automatic in regard to the supply of coal and air, they may be operated with very good efficiency, and when reasonable care is given to the operation, they will burn the high volatile coals with but little, if any, smoke except at the times when they are being cleaned. Owing to the fact that the air is supplied to these stokers under pressure and forced through the fuel bed, it is possible to secure an intimate mixture of the air and gases and to burn within a short distance from the fuel bed. For this reason the combustion space required is usually less than with other types of stokers. In some cases the mistake has been made of installing a stoker too small for the purpose, and the results have been unsatisfactory as the capacity of the boiler could be obtained only with difficulty, the combustion was poor and oftentimes the stack was smoky.

FURNACE EQUIPMENT

There is no other equipment in connection with a power house which requires the same degree of care and experience in its selection to secure satisfactory results as does the furnace equipment, including the design of the boiler and furnace setting. The problem of smoke abatement in power plants is by no means solved when competitive bids are secured from stoker manufacturers and an equipment contracted for, even though smokeless operation is guaranteed by the maker. The draft and the methods of regulating it with both hand and automatic stoker fired plants must always be taken into consideration. The best results are usually obtained when the draft is low because it is less difficult to maintain an even fuel bed and there is less leakage of air through holes in the setting. A great many chimneys are smoky because the draft is insufficient to supply air in the correct proportion at critical periods of operation.

Damper regulators are frequently the cause of smoke, due to the fact that they are not properly adjusted, and it often happens that firemen charge large quantities of coal into the furnace with dampers closed and no air admitted to burn these gases.

Difficulty is also experienced in preventing smoke at times when the load changes rapidly, or when the boilers are heavily overloaded. Oftentimes the furnaces will smoke when boilers are cut out and banked, and they are equally liable to smoke when they are being brought from a banked condition into service.

It is very difficult to start a fresh fire with bituminous coal under a boiler without producing smoke. In cities where there is a smoke ordinance it is quite often the practice to start fresh fires before the smoke inspector is on duty. This problem is being met at the present in some boiler plants, in foundry cupolas and other industrial furnaces, by using a bed of coke, ignited by means of a gas or oil flame from a portable burner installed for the purpose. Such a procedure will build up a fuel bed and bring the furnace walls up to a temperature so that fresh coal may be fired without particular difficulty. This plan is of course more expensive and more troublesome than to start the fire with some kindling and bituminous coal as has been the custom for a long time.

Furnaces may be grouped as follows:

- *a* With iron-enclosed combustion chamber and short gas travel, such as house-heating boilers, internal fire-box boilers, and vertical boilers not provided with extension furnaces.
- *b* With brick side walls, small combustion chambers and short gas travel, such as water-tube boilers with grates directly below the heating surface.
- *c* With iron surfaces of boilers forming roof of combustion chamber, and long gas travel, such as horizontal return tubular, Heine type, etc.
- *d* With brick-enclosed combustion chamber and long gas travel, with special arches, piers, etc., to aid in mixing air and gases.
- *e* With any one of the above types and further equipped with automatic steam jets and air admission.
- *f* With any one of the above types equipped with automatic stokers.

DESCRIPTION OF TESTS

To illustrate the variations in conditions under which coal is being burned, tests were made, and are herewith tabulated in Tables 1 to 7.

The observations in Table 1 were made at an electric light plant on B. & W., boilers, rated at 350 h.p. each. These boilers were set at a height to give about 42 in. between the grate and tubes of the boiler.

TABLE 1 TEST ON B. & W. BOILERS

Time	Draft Back of Boiler	Thickness of Fire	Gas Analyses Per Cent by Volume			Remarks
			CO_2	O_2	CO	
4.03	....	18	....	...	...	Fired 14 shovels coal
4.07	0.10	18	13.6	1.5	2.3	4 min. after firing
4.20	....	18	...	...	...	Fired 15 shovels
4.25	0.11	17	12.5	1.1	3.5	5 min. after firing
4.37	....	18	....	...	...	Fired 14 shovels
4.42	....	18	....	...	...	Raked fire
4.45	0.21	18	13.7	1.0	6.7	3 min. after raking
5.05	....	18	....	...	...	Fired 15 shovels
5.15	0.25	18	18.2	0.6	1.0	10 min. after firing
5.33	....	18	....	...	...	Fired 16 shovels
5.35	0.20	18	15.3	1.0	3.6	2 min. after firing
5.55	....	....	....	...	...	Fired 17 shovels
5.58	0.08	19	12.0	0.3	4.7	3 min. after firing

TABLE 1*a* SPECIAL DRAFT READINGS TO SHOW ACTION OF DAMPER REGULATOR

Time	Draft at Outlet from Boiler	Remarks
p.m.		
6.25	0.06	Damper closed
6.26	0.35	Damper half closed
6.27	0.07	Damper closed
6.30	0.42	Damper open
6.32	0.46	Damper open

It will be seen from the analyses that when several shovelsful of coal are fired at one time, large amounts of carbon monoxid and unburned gas escape from the furnace and that there is also a considerable loss after long intervals if the damper was nearly closed. The stack smoked almost continuously during this period and the smoke was more than 60 per cent black for periods of four or five minutes after each firing. These readings in this table indicate the frequency of changes in the draft due to the action of the damper regulator. Such changes are unfavorable to good combustion. A damper regulator in perfect working order should not permit of such fluctuations in draft. The analysis of coal burned at this plant was as follows:

Moisture	2.69
Volatile	16.30
Fixed carbon	73.99
Ash	6.92
	100.00
Sulphur	0.61
B.t.u.	14,207

These results indicate that the conditions under which the coal was burned were very unfavorable, that the fire was too thick, that too much coal was fired at one time, and that the draft was not properly regulated. The combustion chamber is small and the gases pass directly from the fuel bed to the boiler tubes with but little opportunity to mix the gases from different parts of the grate. With such a furnace it is possible to have too little air on one side and too much air on another. Frequently there will be incomplete combustion and an excess of air at the same time.

TABLE 2 TESTS ON A CLIMAX BOILER

Time		Draft over In. of Water	Steam Pressure	Flue Temp. Deg. Fahr.	Gas Analyses Per Cent by Volume				Air Excess Per Cent
From	To				CO_2	O	CO	N	
a.m.	a.m.								
9.00	9.30	0.11	99	565	12.6	6.2	0.0	81.2	41
9.30	10 00	0.13	98	565	13.8	4.6	0.1	81.5	27
10.00	10.30	0.12	101	595	14.6	4.0	0.2	81.2	23
10.30	11.00	0.11	99	575	14.9	3.9	0.1	81.1	23
11.00	11.30	0.17	97	545	12.6	6.6	0.0	80.8	45
11.30	11.58	0.11	97*	540	13.4	5.5	0.0	81.1	35
p.m.	p.m.								
1.30	2.00	0.17	98	595	12.5	6.3	0.1	81.1	42
2.00	2.30	0.15	100	535	13.7	5.5	0.0	80.8	35
2.30	3.00	0.21	97	535	13.4	5.7	0.0	80.9	37
3.00	3.30	0.18	97	565	11.5	8.0	0.0	80.5	61
3.30	4.00	0.19	98	575	12.9	6.5	0.0	80.6	44
4.00	4.30	0.21	97	570	14.3	4.8	0.1	80.8	29
4.30	5.00	0.17	98	560	14.2	4.9	0.0	80.9	30
5.00	5.30	0.16	99	545	14.5	4.3	0.0	81.2	25
5.30	5.55	0.28	..*	545	14.4	4.7	0.3	80.6	29
Average		0.16	98	560	13.6	5.4	0.1	80.9	35

*Hand damper dropped.

The results in Table 2 were obtained on a Climax boiler, rated at 800 h.p. This boiler was provided with a plain grate, having 125 sq. ft. of surface. The distance between the grate and the boiler tubes was 3½ ft.; the tubes being directly over the fire. The rate of

combustion was low, being approximately 12 lb. of dry coal per sq. ft. of grate. The coal used was of the character shown by the following analysis:

Moisture	2.12
Volatile	16.38
Fixed carbon	75.47
Ash	6.03
	100.00
Sulphur	1.03
B.t.u.	14,431

This furnace is open to the same criticism as that in Table 1, but the results are good because of exceptionally good firing.

TABLE 3 RECORD ON HORIZONTAL RETURN TUBULAR BOILER

Time	Min. after Firing	Coal Fired Shovels	Thickness In.	Draft Furnace	Draft Outlet	Gas Analyses Per Cent by Volume			Remarks
						CO_2	O_2	CO	
10.40	..	8	10	....	....	....	....	....	No smoke
10.45	5	..	..	0.25	0.47	11.6	8.2	0.0	....
10.51	..	7	10	....	....	....	....	....	No smoke
11.00	9	..	..	0.26	0.50	13.8	6.4	0.0	....
11.05	..	9	10	....	....	....	....	....	No smoke
11.13	..	..	..	....	....	....	....	....	Raked fire Trace smoke
11.15	10	..	11	0.25	0.48	13.5	5.8	0.3	....
11.17	..	8	10	....	....	....	....	....	10% smoke ½ minute
11.23	..	8	11	....	....	....	....	....	10% smoke ½ minute
11.30	7	..	..	0.24	0.48	13.2	6.6	0.0	....

Note.—When fire is loosened by bar, smoke as high as 60 per cent is given off for about ½ minute and an average of about 20 per cent for two minutes after.

There were four furnace doors equally spaced around the circumference of the furnace. Coal was fired in quantities of about five shovelsful at a time and at regular intervals. At times just after firing there would be a very thin smoke at the top of the stack. In many cases there was no smoke. On two or three occasions the smoke reached a density of 40 per cent for a period of about one-half minute after firing. This plant was practically smokeless except at times when the fires were banked or when they were broken up after having been banked and when cleaning the fires. It was only for a very short period of time that the smoke was darker than 60 per cent black. This plant smoked about 40 per cent black for one-half minute after firing

when the coal is very wet. Full capacity could not be carried without smoking seriously.

The behavior of the same coal in another plant under a return tubular boiler is shown in Table 3. The boiler was provided with a rocking grate having an area of 36 sq. ft. The fireman was not a highly trained one, but the fires were maintained in good condition and there was practically no somke during the periods of regular operation. The load was nearly constant. This furnace has a long combustion chamber and is not nearly so sensitive to changes in the thickness of the fire or the amount of coal charged at one time as the furnaces described under Tables 1 and 2.

The observations in Table 4 were taken on a 225-h.p. vertical fire-tube boiler of the Manning type, having a grate surface of 41½ sq. ft. and provided with two firing doors and eight steam jets. The distance from the grates to the heating surface is 6 ft. This furnace is similar to those in Tables 1 and 2 and can not be operated at full capacity without smoke unless steam jets are used. The coal burned showed the following composition:

TABLE 4 GAS SAMPLES TAKEN AT POINT WHERE FLUE GASES LEAVE BOILER ROOM

Time*	CO_2	O_2	CO	N_2	Draft, In. of Water		Flue Temp.
					Over Fire	In Flue	
1.00	12.0	8.0	0	80.0	0.30	0.40	470
1.20	11.0	7.9	0	81.1	0.35	0.35	480
1.40	11.8	7.7	0	80.5	0.30	0.30	470
2.00	10.2	9.3	0	80.5	0.30	0.40	490
2.20	11.2	8.3	0	80.5	0.30	0.35	490
....†	12.6	6.2	0.8	80.4	....	...	...
....	12.6	6.6	0.6	80.2	....	....	...
....	11.9	7.4	0.9	79.8	0.25	0.30	490
....	13.5	5.4	0.6	80.5	....	....	...

* Steam jets in operation. † Steam jet off.

Moisture	1.87
Volatile	18.18
Fixed carbon	73.55
Ash	6.40
	100.00
Sulphur	0.63
B.t.u	14,538

Each steam jet draws in a quantity of air through a pipe which surrounds it. Provision is made to regulate the amount of air supplied with the steam. These steam jets are located about $3\frac{1}{2}$ ft. above the grate surface. The thickness of fire is maintained at about 12 in. and the fuel bed is kept as level as possible. Coal is charged in quantities of 8 or 9 shovelsful at a time through one door of the furnace. At intervals of about 8 or 10 minutes, depending upon the load, the other door is charged with a similar quantity of coal. The rate of combustion is about 20 lb. of coal per sq. ft. of grate.

TABLE 5 TESTS ON PLANT HAVING HORIZONTAL RETURN TUBULAR AND STIRLING BOILERS

Time	After Firing	Damper had been Closed or Open	Position of Damper	Draft, In. of Water		Flue Temp. Deg. Fahr.	Gas Analyses Per Cent by Volume				Air Excess Per Cent
				Over fire	In Flue		CO_2	O	CO	N	
STIRLING BOILER											
10.40	4	1	Closed	0.04	0.05	480	12.7	0.9	7.0	79.4	5
10.55	2	9	Open	0.03	0.04	455	13.4	0.5	4.9	81.2	3
11.10	10	24	Open	0.11	0.16	445	7.1	12.1	0.8	80.0	136
1.05	2	5	Closed	0.03	0.04	445	16.2	0.6	0.8	82.4	3
1.20	6	11	Open	0.17	0.26	455	5.5	14.9	0.0	79.6	248
1.35	2	1	Closed	0.03	0.04	420	13.0	1.0	4.6	81.4	5
1.50	8	3	Open	0.09	0.12	420	8.8	9.9	1.9	79.4	90
2.05	5	18	Open	0.08	0.11	410	10.1	8.3	1.4	80.2	65
Average				0.07	0.10	440	10.8	6.0	2.7	80.5	69
HORIZONTAL RETURN TUBULAR											
2.30	5	43	Open	0.16	0.23	455	11.5	8.5	0.0	80.0	68
2.45	0.05	58	Open	0.09	0.13	450	13.4	7.0	0.0	79.6	50
3.00	0.05	73	Open	0.15	0.21	475	13.3	5.5	0.0	81.2	35
3.15*	2	88	Open	0.13	0.19	500	15.0	3.8	0.4	80.8	22
3.30	2	103	Open	0.15	0.22	490	12.6	7.2	0.0	80.2	52
3.45	12	9	Closed	0.14	0.20	450	11.6	8.8	0.0	79.6	73
4.00	7	24	Closed	0.13	0.17	460	12.1	8.0	0.0	79.9	62
Average				0.14	0.19	470	12.8	7.0	0.1	80.1	52

	Stirling	Horizontal Return Tubular
Average thickness of fire, in.	11	9
Average weight of coal fired each time, lb.	65	55
Average interval between firings, min.	9	7
Intervals between firings vary		
from, min.	3	2
to, min.	18	16
Per cent of time damper		
open	60	80
closed	40	20
Lb. of coal burned per sq. ft. of grate surface per hr.	10.3	14.5

*Sliced fire 3.14½

To determine the effect of the steam jets, observations were taken with and without them.

With the steam jets on there was practically no smoke issuing from the top of the stack and it would be classed as a smokeless plant. Without the steam jets, it will be noted that there was considerable unburned gas and there was smoke varying from No. 1 to No. 3, Ringelmann's chart. While this would not be classed as a dense black smoke, and would not be subject to a fine under most city ordinances, it would indicate that a little carelessness on the part of the fireman would without doubt cause dense smoke and subject the plant to fines.

The observations in Table 5 were taken in a boiler plant burning coal which analyzed as follows:

Moisture	3.38
Volatile	20.32
Fixed carbon	66.94
Ash	9.36
	100.00
Sulphur	2.22
B.t.u.	13,528

The plant was equipped with a 150-h.p. horizontal return tubular boiler having 33 sq. ft. of grate area, and a Stirling boiler rated at 225 h.p., having a grate area of 48 sq. ft. The draft was regulated by means of a damper regulator operating on individual dampers on each of the boilers.

TABLE 6 B. & W. TYPE BOILER HAND-FIRED

Time	Draft		Temperature Flue Gas	Thickness of Fire, In.	Shovels Fired	Min. after Firing	CO_2	O_2	CO
	Furnace	Boiler							
2.20	0.37	0.46	675	5	18	..	..	..	..
2.25	..	..	765	..	..	5	7.5	11.9	0
3.00	0.36	0.47	725	5	16	..	..	..	..
3.04	..	..	745	..	..	4	7.3	12.0	0
3.25	0.37	0.48	680	6	17	..	..	..	..
3.27	..	..	..	..	..	2	8.1	9.6	1.2

Note.—This plant smoked 100 per cent black for about 2 minutes after each firing, and did not clear up for 5 or 6 minutes. Average period between firings about 10 minutes.

During the time the observations were taken on the Stirling boiler the load was light and the damper was closed most of the time. The stack smoked badly during this period. During the period of observations on the horizontal return boiler the greater part of the load was placed on it. A higher rate of combustion was maintained and

economical operating conditions resulted. It is probable if this boiler had been operating alone that the amount of smoke would have been greatly reduced.

It will be noted that the damper on the horizontal return tubular boiler did not close sufficiently to reduce the draft. The method of firing in this plant was very poor; there was too much coal fired at one time and the intervals between firings varied from 2 to 18 minutes. This is too great a variation. The firemen paid no attention to the position of the dampers and coal was charged in large quantities when the damper was closed. This coal on being heated gave up its volatile gases, a large part of which passed to the stack without burning on account of the limited supply of air, due to low draft. This of course caused dense smoke and an enormous fuel loss. The calculated loss due to carbon monoxid in the flue gases from the Stirling boiler amounted to approximately 11.5 per cent.

The observations in Table 6 were made on a B. & W. boiler rated at 200 h.p., provided with rocking grates 6 ft. by 6 ft. Coal was burned at an average of 18 lb. per sq. ft. of grate.

It was the practice of the firemen to charge a large quantity of coal at one time and to allow the bed of fire to burn low before firing again. This practice is bad in any case, but with the high volatile coal burned, the results show a very poor economy. The plant smoked badly after each firing. The coal used was of the following composition:

Moisture	1.55
Volatile	31.11
Fixed carbon	55.55
Ash	11.29
	100.00
Sulphur	2.69
B.t.u	13,324

These examples serve to emphasize the importance of favorable kinds of coal, careful firing and large combustion chambers. Many others might be given but these represent typical cases and indicate how inefficiently most of the boiler plants are being operated. On the other hand it will be observed that with careful firing results are obtained which compare favorably with plants in which automatic stokers are being carefully operated. The best results were obtained with plants burning low volatile, low ash coals, and with loads which were practically constant, and usually below the rated capacity of the

TABLE 7 RESULTS TAKEN FROM U. S. GEOLOGICAL BULLETIN

No.	Special Device	Design Furnace	Coal	Size	Coal per Sq. Ft.	Kind of Boiler	Per cent Smoke	Above 60% Min. per Hr.	Remarks
216	Steam Jet	Plain	..	Screenings	..	B. & W. Type	..	0	Six $\frac{1}{8}$″ steam jets. Smokes 10 to 20% for $\frac{1}{2}$ min. Success due to careful operation.
227	None	Corrugated Flue	..	R.o.m.	9.5	Scotch Marine Type	4.2	0	Air admission at bridge wall.
240	Steam Jet	Plain	W. Va.	R.o.m.	12.7	Stirling	3.0	0	Steam jets continuous. Twenty $\frac{1}{64}$″ jets to furnace.
215	Steam Jet	Dutch Oven	W. Va.	Slack	17.1	B. & W. Type	..	0	Eight $\frac{1}{8}$″ steam jets to each furnace. Observations include some 10, 20 and 40% readings.
231	None	Dutch Oven	Ill. W.	Fine	25.0	Water Tube	12.6	13	Large combustion chambers. Furnace doors cracked after firing.
217	None	Dutch Oven	..	Slack	12.5	B. & W. Type	5.7	0	Usually burn half anthracite to keep down smoke.
218	None	Brick Furnace	Ill.W.	Fine	32.1	Heine Type	5.3	3	Dorrance design. Total length of brickwork over furnace 11.25 ft.
233	None	Brick Furnace	Ill.	Nut	27.0	B. & W. Type	0	0	Long sloping brick arch (Dorrance).
221	None	Down Draft	W.Va.	Screenings	..	Heine Type	..	0	When coal is fired. Occasionally on lower grate, smokes 40 to 60% about 1 minute.
226	None	Down Draft	Ind.	Screenings	31.0	Scotch Marine Type	7.9	4	Ash pit doors opened a little.
225	None	Coking Furnace	Ill.W.	Nut	10.0	Scotch Marine Type	..	..	Burke design. Stack clear except for short time after cleaning, 40 to 60% black smoke.
237	None	Coking Furnace	Ind.	R.o.m.	24.0	Stirling	0	0	Burke design. Large coking capacity.
255	Steam Jet	Plain	Ohio	R.o.m.	14.7	H.r.t.	1.3	0	Arch in combustion chamber. 12 automatic steam jets on 5 or 6 minutes at each firing.
262	Steam	Plain	W.Va.	R.o.m.	14.0	H.r.t.	0.1	0	Large combustion chamber. Jets not automatic. Careful firing.
263	None	Plain	W.Va.	R.o.m.	13.0	H.r.t.	..	0	Large coal. Special brickwork on bridge wall. Less than 20% smoke 1 min. after firing.
265	None	Plain	W.Va.	Screenings	11.5	H.r.t.	..	0	Smoke observations include some 10, 20 and 40% readings.
266	None	Plain	W.Va.	Slack	13.5	H.r.t.	..	0	Coal cokes and requires frequent poking. Smokes 60% and less about 1 minute after each firing.

boilers. It is demonstrated that plain hand-fired furnaces may under very favorable circumstances be operated without smoke, but that under ordinary conditions they will be inefficient and smoky.

The results in Table 7 are from U. S. Geological Survey Bulletin 373. During the investigations of smokeless plants it was noted that very few plants were being fired by hand without smoke unless steam jets were used for at least a minute or two after each firing. Some plants were doing fairly well without steam jets, but they were in many cases burning large-sized coal and admitting an excess of air, or they were operating at low capacity. Some of the better operated plants were not smokeless but the stacks smoked only for one or two minutes after each firing, beginning with a density of about 60 per cent black and diminishing to about 20 per cent at the end of a half minute. Such plants are not usually subject to fines.

GENERAL DEDUCTIONS

General deductions may be drawn as follows:

a Plain hand-fired boilers may be operated with but little smoke with low volatile coals, or in some cases, with other coals if the rate of combustion is low.

b Hand-fired furnaces with brick arches, etc., are more easily operated without smoke than the plain furnaces.

c Almost any hand-fired furnace may be operated by means of steam jets so as to produce but little smoke.

d While all of the above may be accomplished with a skilled fireman, such plants cannot be depended upon for smokeless results at all times.

e Stokers without suitable combustion chambers or when improperly operated may be expected to smoke.

f Experience has demonstrated that the best stokers properly installed are superior to hand-fired furnaces for economy and smokelessness.

As will be seen from these results, it is possible to burn low volatile and low ash coals with nearly the same efficiency at moderate rates of combustion as may be expected with mechanical stokers when operated by firemen equally skilled. This condition makes it difficult to induce the owners of small plants to install stokers unless they do so for the purpose of reducing the smoke. In a large plant the expense of installing stokers is fully justified because of the saving in fuel and labor. They may in a sense be considered as part of the coal-handling

machinery. The large plant has the benefit of the best engineering talent in the design and construction, and of expert engineering advice and supervision throughout its period of operation. The economy in handling coal and ash, the economy due to a higher order of supervision made possible by the size of the plant, the reduction of labor, and the advantage of buying supplies in large quantities, reduce the cost of power. Incidentally, the plant may be operated with less smoke than a number of small units of the same horsepower located in individual plants.

The average business man does not maintain a power plant from choice but from necessity. If he were able to purchase heat as well as light and power he would gladly pay for service from a central station. This would relieve him of the main details connected with the management of his steam plant and would give him the space occupied by the plant for use in his regular line of business.

The growth of the central heating business has been rapid during the past five years in some localities, and there seems to be a tendency on the part of manufacturers and merchants to purchase heat in case it can be obtained at or near the figure which it costs them to produce it.

It is perfectly logical to expect a reduction of smoke within a few years due to the adoption of systematic plans for numerous heating and lighting stations so distributed in each large city as to serve the business districts with light, power and heat economically. These stations could probably be most economically operated if they generated only enough steam for heating and were arranged as sub-stations to take excess electric current required from a central power house so located as to generate current at the lowest cost.

COMCLUSIONS

The smoke from power plants may be greatly reduced by adopting the following methods:

a Use low volatile coals or mixtures of bituminous coal with coke or anthracite in all hand-fired furnaces. Use steam jets if necessary to prevent smoke at high rates of combustion.

b Use automatic stokers in all plants in which the expense can be offset by the saving due to better combustion, a reduction of labor and the use of cheaper fuel.

c Build central plants for heat, light and power to replace the numerous small boiler plants in the business districts of our cities.

FURTHER DISCUSSION

E. G. Bailey. Although the Ringelmann smoke chart has been used for many years as a standard of measurement, it has only recently received the attention which it deserves. The error caused by the personal factor of the observer, which is much smaller than is generally believed, is due to the color of the smoke being sometimes of a brownish cast as compared with the jet black ink used in making the charts. It must be remembered that smoke corresponding to

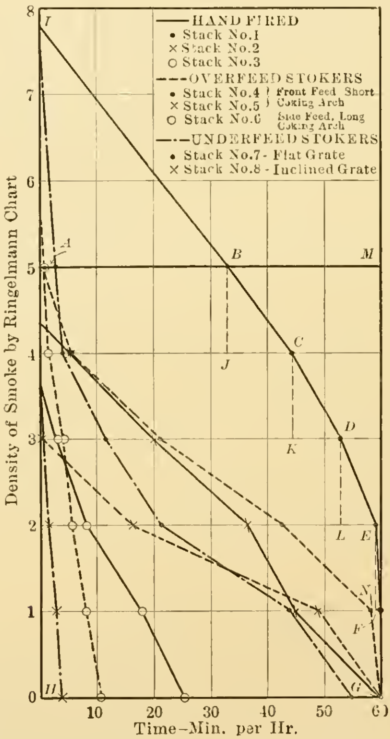


Fig. 1 Plot of Observations Given in Table 8

No. 1 must allow 80 per cent of light to pass through it; No. 4 passes 20 per cent of light; No. 5 is opaque regardless of exact matching of color shades.

When comparing smoke with the chart, the density of smoke should be as dense or denser than the number assigned it, yet not so dense as the next higher number. For instance, if smoke is denser

than No. 3, and not so dense as No. 4, it should be recorded as No. 3. Likewise, if smoke being emitted from a stack is not so dense as No. 1, it should be recorded as − 1 or + 0. The density of the smoke is obtained by averaging all readings and expressing the result in percentage of smoke on the basis of No. 5 being 100 per cent, but this method gives very little idea of the nature of the smoke. Ringelmann chart readings are usually taken at ½-min. or 1-min. intervals during the period of an hour or more and the readings plotted in the form of a log. The plotted continuous log gives a very good general idea of the manner and regularity of the smoke emission, but it is very unsatisfactory for comparing one stack with another, or the same stack from time to time.

An additional method which the writer has used to good advantage for several years is to plot a series of readings as one characteristic curve. This is done by adding the total number of readings of each different density and reducing them to a basis of minutes per hour. To the number of minutes corresponding to each density is added all the minutes corresponding to the greater densities and plotting Ringelmann chart numbers as ordinates, and minutes as abscissae. For example, in Fig. 1, stack 7, the readings of a 2-hr. period reduced to minutes per hour were as shown in Table 8.

TABLE 8 SMOKE OBSERVATIONS—STACK 7

Density, Ringelmann Chart No.	Smoke of Each Density Emitted, Min.	Smoke of Each Density and Darker Emitted, Min.
5	2.5	2.5
4	1.0	3.5
3	8.0	11.5
2	9.5	21.0
1	23.0	44.0
−1+0	10.5	54.5
0	5.5	60.0
	Total 60.0	

The values in the last column are plotted as abscissae on the lines corresponding to the different density numbers, and the curve drawn through these points indicates the general character of the smoke being emitted.

The curves in Fig. 1 represent a variety of plants located in different places with various equipment, but all burning semi-bituminous coal with volatile matter between 17 and 21 per cent. Most of these data

were obtained in connection with the drafting of the smoke bill recently enacted for Boston through the effort of the Fuel Supply Committee of the Boston Chamber of Commerce. Detailed information relative to the rate of combustion, number of boilers in operation, flue gas analysis, etc., is lacking in these cases, but they are given to show the different characteristics of different equipment and operating conditions.

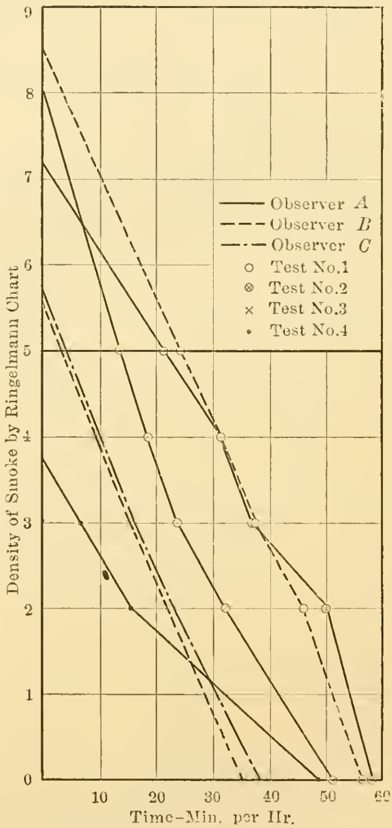


Fig. 2 Characteristic Smoke Curves from Internally Fired Boiler

Stacks 1, 2 and 3 (Fig. 1) are connected with hand-fired boilers, and the curves show the same general rate of gradation, but there is a great difference in the total amount of smoke produced from each. Stack 1 emitted No. 5 smoke for 33 min.; No. 4 smoke and darker, $44\frac{1}{2}$ min.; No. 3 smoke and darker, 53 min.; No. 2 smoke and darker, $59\frac{1}{2}$ min.; and No. 1 smoke and darker, 60 min. per hr. No. 5 on the

Ringelmann chart includes all smoke that is opaque, and for a stack of a given diameter a certain amount of carbon particles per cubic foot is necessary to make this smoke opaque, but twice as much carbon or smoke could be carried per cubic foot of gas without changing the readings. This point is graphically brought out in these characteristic smoke curves. For instance, stack 1 would not be likely to produce smoke of No. 5 density, no more or no less, for 33 min. out of 1 hr., but during a part of this time it is undoubtedly much denser, as indicated by projecting the curve back until it intercepts the zero line at a density of eight. The exact nature of the extended

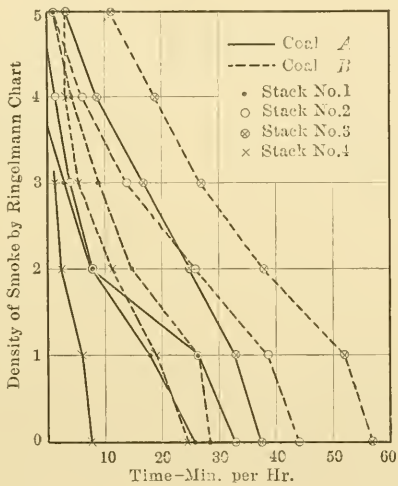


FIG. 3 SMOKE EMITTED FROM FOUR DIFFERENT STACKS ON TWO 11-HR. TESTS

part of this curve is problematical, but it illustrates the point that the average density of smoke may be much greater than is indicated by merely averaging the readings in the usual method. The average density of smoke, as compared with No. 5 by the Ringelmann chart as a basis, is the area *HIBEG* divided by *AMGH*, or 103 per cent.

If the area representing smoke denser than No. 5 is neglected, we have area *ABEGH* divided by *AMGH*, or 87.8 per cent. If the usual method of averaging smoke readings, such as was apparently used in the U. S. Geological Survey Bulletin No. 373, be applied to this stack we get only 83.3 per cent. This error is due to the omission of the triangular areas *BJC*, *CKD*, *DLE* and *ENF*, which properly belong in the area representing the total smoke emitted. All of the No. 4 readings representing the $11\frac{1}{2}$ min. from *J* to *C*, were as dense

as, or denser than, No. 4, and less than No. 5, so they would naturally be distributed along the diagonal line BC, and the same holds true with respect to the other parts of the curve. Applying the averaging method to the curve representing stack 5 (Fig. 1), 21.8 per cent of smoke is obtained, while the true average from the area is 31.8 per cent. The flatter the curve, the greater is the error caused by the use of the averaging method as usually applied, and the result is always too low.

Stacks 4, 5 and 6 are connected with stoker furnaces of the overfeed type, the first two having short coking arches with front-feed. The plants are similar with respect to the number of boilers and size

TABLE 9 GENERAL DIMENSIONS AND EQUIPMENT OF EACH STACK

Stack	Stack Diameter, Ft.	Number of Boilers Connected	Type of Boilers	Total Rated Boiler H.P.	Total Grate Area Sq. Ft.	Method of Firing
1	8	6	h.r.t.	900	204	hand-spreading
2	$7\frac{1}{2}$	8	h.r.t.	1200	272	hand-spreading
3	4	1	porcupine	300	56	hand-spreading
4	7	7		1050	235	hand-spreading

of stack, but the relative rates of combustion, volatile matter in coal, etc., are not known. Stack 6 had only one furnace of side-feed type with a long coking arch connected with it.

Stacks 7 and 8 are connected with under-feed stoker No. 7, having five stokers with flat grates, and stack 8, having three stokers of the inclined grate type.

No specific conclusions as to the value of the different methods of firing should be drawn from the curves in Fig. 1, since they are merely given to show the great variation that exists in actual practice between plants with similar equipment.

The characteristic smoke curves in Fig. 2 were all taken from the same stack connected with an internally-fired boiler of the locomotive type. The same kind of coal was fired by the same fireman, using the spreading method, in each test. The only changes made on the different tests were in the amount and temperature of secondary air supply. The coal used on these tests contained about 30 per cent of volatile matter, and over 50 lb. of it were burned per square foot of grate per hour.

The agreement between different observers is shown in Tests 1 and 3. Observers A and C had had very little experience in the use of

the Ringelmann chart, and neither knew that observer *B* was taking readings.

The curves in Fig. 3 represent the smoke emitted from four different stacks at one plant on two 11-hr. tests made on consecutive

TABLE 10 GENERAL DATA REGARDING SMOKE PRODUCED

a Coal fired		*A*	*B*
b Analysis of coal		Per cent	
(1) moisture		4.81	5.40
(2) volatile		16.22	18.81
(3) fixed carbon		70.40	69.00
(4) ash		8.57	6.97
(5) sulphur		1.20	0.70
c B.t.u.		13,639	13,838
d Average draft in firebox			
	Boilers of Stack	In. of Water	
	1	0.45	0.32
	2	0.25	0.31
	3	0.30	0.32
	4	0.21	0.27
e Coal fired per sq. ft. grate per hr.		Lb.	
	1	15.1	13.8
	2	11.9	11.8
	3	19.6	16.5
	4	9.2	11.7
f Flue gas analysis CO_2		Per cent CO_2 Volume	
	1	8.1	7.7
	2	6.9	7.4
	4	7.4	9.5
g Flue gas analysis CO		Per cent CO Volume	
	1	....	....
	2	....	0.05
	4	....	0.20
h Air excess from flue gas analysis		Per cent	
	1	137.0	146.0
	2	180.0	149.0
	4	155.0	87.0
i Smoke with No. 5 on Ringelmann chart as 100 per cent, from Fig. 3.			
	1	13.8	22.8
	2	18.2	35.8
	3	34.7	56.0
	4	4.3	17.2

days. The tests were primarily made to determine the comparative values of the different coals from the evaporation on the entire plant, and the firemen gave no attention whatever to the amount of smoke made.

Table 9 gives the general dimensions and equipment connected with each stack, and Table 10, the general data which have direct bearing on the amount of smoke produced. All conditions were maintained as nearly uniform on the two tests as the daily operation of the plant would permit, the only intended change being in the coal burned. The principal difference between the coals so far as smoke was concerned is in the percentage of volatile matter, which was 16.22 and 18.81 in coals *A* and *B* respectively as fired, or 17.04 per cent and 19.88 per cent on the dry basis. Owing to changes in the draft and the amount of clinker formed, the rate of combustion was not quite the same for the two tests. There was also some change in the flue gas analysis and air excess. The gas samples were taken from the main flues and included considerable leakage of air through the boiler settings. No gas analysis was made from stack 3.

The curves in Fig. 3, and *i* derived from them, indicate very clearly the increased amount of smoke due to an increase of 2.8 per cent in the volatile matter. The increase in smoke from stacks 1 and 3 was proportionally less as compared with the increase from stack 2, owing to the lower rate of combustion in stacks 1 and 3 with coal *B*, as compared with coal *A*, while the rate was practically the same for both coals in stack 2. The amount of smoke from stack 4 was four times as much with coal *B* as with coal *A*, due to an increase in the volatile matter of the coal, rate of combustion and decrease in the excess of air.

Slight differences in the percentage of volatile matter, rate of combustion, air excess, method of firing, etc., are found to have a marked effect upon the amount of smoke produced when the characteristic curves are drawn. By the use of such data and curves, it is possible to determine the relative importance of the different factors affecting this problem, and to take intelligent steps to reduce the density of smoke to the desired limits.

The time and density limits incorporated in the law for the abatement of smoke recently enacted for Boston and its vicinity have been worked out along this line and are possible of attainment in everyday practice if the conditions of individual plants are properly studied and changes intelligently made.

Frederic H. Keyes said that the power plants of New England are so situated that the use of anything but bituminous coal is impossible; and unfortunately the price is usually the controlling factor rather than the quality, a fact largely responsible for the amount of smoke. Some of the largest users of bituminous coal have already found it advantageous to buy their coal under specifications especially drawn up to meet their requirements. This would seem to be the first step in the right direction, so far as smoke is concerned. The next step is to fire and burn it properly. Here the coöperation of the fireman is absolutely necessary. If he could be induced to regard the problem from the standpoint of the man who pays the bills the results would be entirely satisfactory. From personal experience and observation he knew that in plants where a good system of firing was followed, satisfactory results were obtained with a reasonable amount of supervision and without any other special devices. Next to the fireman the quantity of air, together with the manner and conditions under which it is mixed with the products of combustion, is of the greatest importance. This is a point which must be determined for each individual case according to the kind of coal used and the general conditions governing the operation of the plant. It is a fact that under favorable conditions a good grade of bituminous coal can be burned without making smoke, and under other conditions the results are satisfactory if mixed with anthracite screenings or coke breeze. It is believed that special devices such as steam jets and fire-brick arches, with few exceptions, usually cost more to operate and maintain than can be saved through the use of low grade fuel, for which some such special device is almost always required in order to obtain even approximately satisfactory results. While it is believed that greater care in the purchase of coal and the setting of boilers will accomplish much in the way of preventing smoke, more can undoubtedly be done by educating the fireman to the proper use of the fuel given him.

Charles H. Manning. The use of under-feed stokers deserves more consideration than Mr. Randall gives it, not so much for smoke prevention as for economy. Such stokers heat the fuel slowly and the hydro-carbons are gradually gasified, which allows of their combustion as they pass up through the incandescent layer of fuel above them; whereas in hand-firing they flash into gas as the coal is thrown on top of the fire, and pass off largely unconsumed, increasing the smoke. It is true that these stokers are used to less advantage in

power plants running intermittently since they smoke when the furnace door is opened during the last hour of the run to break down the fire.

It is believed that with hand-firing the fixed carbon is a better guide to the value of the fuel than the British thermal units, which is a useful guide, however, for under-feed stokers.

HENRY BARTLETT. I wish to speak of the problem of smoke abatement from the standpoint of the railroad man, giving some of the reasons for making smoke, the difficulties in mitigating it, and some of the remedies applied.

We have in the locomotive itself an overworked power plant. The boiler is restricted in dimensions, operated under forced draft at all times and compelled to burn 100 lb. or more of coal per square foot of grate per hour as compared with the stationary plants burning 10 or 20 lb. The locomotive boiler is called upon for ranges of work greater than that of any other service. One moment the locomotive may be quietly standing in the roundhouse with the banked fire and only 40 or 50 lb. of steam on the boiler, and within an hour it may be running on the road with its 200 lb. of steam and exerting its maximum power. It may be moving along and handling its heavy train, emitting little smoke, when the next moment it is suddenly stopped by a signal or flag, or required to take a siding to meet an opposite train. Under such changes it is impossible to eliminate the smoke, since the large body of coal necessary to perform the work keeps on emitting the volatile gases until they have disappeared. The terminals of runs are necessarily in large cities and here the locomotives are housed and have their fires cleaned and built up, all of which involves dirt and smoke. For these reasons it is impossible to burn bituminous coal in locomotive service without some smoke.

The only smokeless fuels available are anthracite coal, coke and oil. Should the railroads resort to the use of the first, the supply would be insufficient, since Pennsylvania mines only 70,000,000 tons annually, or less than the amount of coal consumed by the locomotives per year, and secondly, the price would so advance as to render the cost prohibitive. While coke is smokeless, that is its principal claim for merit, since on account of its other qualities, it has only about 80 per cent of the efficiency of bituminous coal. Oil properly fired is a smokeless fuel and is largely used by the railroads adjacent to its source, but it is also limited in supply and the cost of its transportation would make it prohibitive for general use. Smoke-consuming

devices have so far been unsuccessful and the only thing of this kind in use today is the brick arch, which increases the course of the gases and delays their departure from the firebox, thereby assisting in their combustion.

I believe the real and only solution of the smoke problem is the education and supervision of the engineer and fireman. It is a joint problem between the two, for negligence on the part of one can defeat the good efforts of the other. This education on a big railroad is a great problem and involves the continuous efforts of a large number of officers. The railroads are at all times putting forth every energy and sparing no expense to reduce smoke to a minimum. As a result I believe I am safe in saying that great improvement has been made.

George H. Barrus. The gases first evolved from a charge of coal thrown on a hand-fired furnace are in their original cold state. Contact with the hot atmosphere and radiant heat of the furnace increases the temperature of the exposed portions of the gases sufficiently to ignite them, and these take fire and burn away. Portions of gas which are not favorably exposed receive an insufficient quantity of heat to become thoroughly ignited, and these pass out of the furnace in an unconsumed state. It is the unheated gas thus formed which causes smoke, and the whole problem of smoke prevention lies in overheating, so to speak, these gases before leaving the combustion chamber, so that they will ignite. When these gases receive a proper amount of heat before reaching the boiler, they are burned without smoke, and the degree of smokelessness obtained depends on the degree with which the heating of the gases has been effected.

This feature of the subject may be illustrated by referring to an experiment I have made on a battery of two 300-h.p. vertical-pass horizontal water-tube boilers. The result aimed at was to ascertain the effect of firing the two boilers alternately and employing the incandescent coke of one furnace as a medium for overheating the gases evolved from fresh charges of coal in the other. An opening was cut through the intermediate wall between the two furnaces, extending horizontally the whole length of the grate and vertically to the lower row of tubes, putting the two furnaces into free communication. The closing of either of the flue dampers was sufficient to cause the products of combustion from the furnace of one boiler to pass through the intermediate opening and over the fuel bed of the other furnace, and thereby to secure the desired object. To make a comparison of the

smokelessness of this system with the ordinary system of operation the boilers were first run in their usual manner. The coal was New River and one boiler was fired at a time. The firing system employed consisted in charging the two outside doors first, there being three doors in all for each boiler, and then waiting a short time before charging the middle door.

Smoke observations were made every minute for a continuous period of two hours, the estimated percentage of black smoke being judged as it appeared to the eye when escaping from the top of the chimney. With the boilers operated in the ordinary manner, the average amount of smoke observed for the entire period of 2 hr., including the time when there was no smoke, was 13.6 per cent. The maximum amount was 75 per cent, and there was an entire absence of smoke, or only a trace of it, 54 min.

When the alternate system was brought into use, the three doors of each boiler were fired in rotation, there being no wait between doors. Smoke observations showed that the average amount of smoke during the entire period of 2 hr., including the time of no smoke, was 2.3 per cent. The maximum amount was 10 per cent, and there was an entire absence of smoke, or only a trace of it, 1 hr. 22 min. It will be observed that the latter method produced a marked effect upon the character of the smoke, reducing its density and the length of time it was visible. It may be added that by actual observation the smoky flame leaving the new coal was seen immediately to clear up on passing into the secondary furnace.

John T. Hawkins. There can be very little doubt that the suppression of smoke is a desideratum and a great one, if it is for physical reasons only; but there has been, I think, a great deal of exaggeration as to the economy of smokeless combustion. In the products of combustion from bituminous coal there are not only losses from fixed carbon, the real smoke, but from uncombined carbon in the form of CO. As far back as 1874 or 1875 there was great furor in and around New York, about reducing the smoke from soft coal, and many extravagant claims were made as to the losses in burning bituminous coal. Theron Steel, a graduate of the first class of engineers from the Naval Academy, and myself conducted in 1874 to 1875 in New York a series of experiments to determine what was the difference in economy between the heaviest, smokiest firing that could be made and absolutely clear, smokeless firing with bituminous coal. The apparatus was especially prepared and set up in such a way that

perfectly transparent white-hot gases could be made to pass out of the combustion chamber and the boiler tubes with no sign of smoke issuing from the chimney at any time. We could also fire for an extreme amount of smoke. There were peep-holes arranged to permit the examination of the character of the combustion and of the escaping gases. All kinds of coal were used, and the analyses were exhaustive in every way. The results were that we found that between the most smoky fire we could make by hand-shovel firing, and the clear smokeless fire, there was never more than a loss of about 0.7 of 1 per cent, more than half of which was due to the increased escape of CO, which always obtained with smoky firing. The greatest actual loss of fixed carbon was, therefore, only about 0.3 of 1 per cent, which shows that the economy feature of the smoke problem is of little importance.

If this loss were as great as Mr. Randall quotes in his paper (3 to 6 per cent) attempts would have been made long before 1874 or 1875 to do away with bituminous smoke, and the question would today be a much more agitated one than it really is.

Chas. H. Bigelow. In looking over some old drawings dating as far back as 1785, we find that smoke abatement is not a new problem, but one that inventors have been working on ever since that time, and many and varied are the methods suggested for decreasing it.

James Watt in 1785 proposed hot funnels or pipes filling the space between the top of the bridge wall and the bottom of the boiler; J. & J. Roberton in 1800 introduced tubes in the front wall to admit cold air over the fire. In 1809 to 1812, perforated pipes located in the bridge wall and extending through the side walls were tried. A little later, methods of introducing air from the ash pit through the bridge wall and baffles back of the bridge wall were experimented with. In 1816, W. Losh proposed to divide the fire longitudinally and to pass the gases from one fire under the grate of the other. In 1838, D. Cheetham introduced a fan to draw the gases from the back of the bridge wall and to mix them with fresh air blowing them again through the fire. A deflecting arch over the fire was tried by R. Rodder in 1838. A coking plate in front of the furnace was designed by Howard and Sons, in 1840. J. Smethurst planned to draw the gases through a water chamber back of the bridge wall by means of an exhaust fan. J. Nutt placed a small secondary boiler back of the bridge wall to be heated by the gases, discharging the steam produced into the hot gases through a perforated pipe thus furnishing oxygen,

the gases being mixed by numerous baffle walls. In another method proposed by Johnson, a water tank divided into four sections is located back of the bridge wall and the gases deflected on the surface of each section by hanging walls. The water is thrown into the current of gases in the form of a spray by dash wheels, and is combined chemically with them. Many other methods were proposed from time to time including two grates in series and one above the other, also many different methods of introducing air into various parts of the combustion chamber and behind the bridge wall.

D. T. Randall. Nearly all these statements have been based on observations and experience with a particular apparatus and with fuels of the same general character. The various experiences in individual plants only emphasize the fact that burning bituminous coal efficiently without smoke is as important a problem as any which claim the attention of mechanical engineers.

It is possible to operate some plants smokelessly and at the same time inefficiently. Many plants are so designed that when operated to secure the highest economy, some smoke will be emitted from the stack and only a slight change in the conditions in the boiler room will cause them to smoke badly.

General conclusions regarding the smoke problem should not be based upon such plants alone. There has been considerable progress made in the design of furnaces during the past five years and there are many plants now operating in which bituminous coal is burned efficiently and without objectionable smoke.

GENERAL NOTES

AMERICAN SOCIETY OF CIVIL ENGINEERS

At the opening session of the 58th Annual Meeting of the American Society of Civil Enginers in the Society house at 220 West 57th Street, New York, January 18, 1911, annual reports were received and progress reports from the special committees on Steel Columns and Struts and on Bituminous Materials for Road Construction were presented for discussion. The following officers were elected for the year 1911–1912:

President, M. T. Endicott; Vice-Presidents, A. P. Boller, Mem.Am.Soc.M. E., C. L. Strobel; Treasurer, J. M. Knap; Directors, G. C. Clarke, H. G. Stott, Mem.Am.Soc.M.E., J. P. Snow, Robert Ridgway, L. W. Rundlett, W. H. Courtenay.

Two excursions occupied the afternoon, one to the plant of the Keuffel and Esser Company, Hoboken, N. J., where all kinds of scientific instruments used by engineers are manufactured; and the other to the Brooklyn Navy Yard. In the evening the President held a reception at the Society House, followed by informal dancing.

On Thursday the entire day was spent in a visit to the works of the Bethlehem Steel Company at Bethlehem, Pa., where inspection was made of the structural mill and the rolling of structural shapes; the rail mill and the rolling of open-heart steel rails; the ordinance works and the forging of guns and armor plate; the gun finishing machine shop where large guns and heavy machinery are under construction; two modern blast furnaces under construction; also the construction of a power plant for gas-driven electric power and gas power blowing engines. Luncheon was served at the works and the party was conveyed to and from Bethlehem by special train. An informal smoker on Thursday evening at the Society House completed the program of the convention.

Special meetings for topical discussion were held on Friday and Saturday, January 20 and 21, immediately following the convention, with Road Construction and Maintenance as the subject under consideration, and the following sub-divisions: Preliminary investigations, introduced by Logan W. Page; Relative Value of Three Methods of Carrying on Work, introduced by Harold Parker; Systems of Maintenance, introduced by Hubert K. Bishop; The Use of Water, Calcium Chloride, Light Oils, etc., as Dust Palliatives introduced by Samuel Whinery, Mem.Am.Soc.M.E., Surface Treatment with Tars, Heavy Oils, etc.,introduced by Charles W. Ross; The Use of Bituminous Materials by Penetration Methods, introduced by Walter W. Crosby; The Use of Bituminous Materials by Mixing Methods, introduced by Arthur H. Blanchard. A number of engineers especially interested in Road Construction were present and a very full discussion resulted.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

On Friday, January, 13, 1911, the subject of Corona was presented for consideration at the monthly meeting of the American Institute of Electrical Engineers, with two papers, one by Prof. Harris J. Ryan, Mem.Am.Soc.M.E., on Open Atmosphere and Dry Transformer Oil as High Voltage Insulators, and the other by E. L. West, on High Voltage Line Loss Tests made on 100-kilowatt, 60-cycle, 180-mile Transmission Line of the Central Colorado Power Company.

The Mid-Year Convention will be held in Pittsfield and Schenectady from February 14-16, 1911, and will be devoted to a consideration of the following papers: Mechanical Forces in Magnetic Fields, C. P. Steinmetz, Mem.Am.Soc. M.E.; Problems in the Operation of Transformers, F. C. Green; Protection of Electric Transmission Lines, E. F. C. Creighton; Tests of Grounded Phase Protector on the 44,000 Volt System of the Southern Power Company, C. I. Burkholder and R. H. Marvin; Tests of Losses of High Tension Lines, G. Faccioli; The Temperature Gradient in Oil-Immersed Transformers, James Murray Weed; Hysterises and Eddy Current Exponents for Silicon Steel, W. J. Wooldridge; Commercial Problems of Transformer Design, R. H. Wilson; Design, Construction and Test of an Artificial Transmission Line, J. H. Cunningham.

NEW ENGLAND WATER WORKS ASSOCIATION

The New England Water Works Association held its annual meeting on January 11, 1911, at the Hotel Brunswick, Boston, Mass. Reports were presented by the following committees: To look after and keep track of Legislation and other matters pertaining to the Conservation, Development and Utilization of the Natural Resources of the Country, M. N. Baker, Chairman, New York City; to prepare a Standard Specification for Fire Hydrants, H. O. Lacount, Mem.Am.Soc.M.E., Chairman, Boston; On Information as to the Conditions under which Extensions of Water Mains are made by Town Owned Water Supplies, Charles W. Sherman, Chairman, Boston; On Uniformity of Hose and Gatenuts and Direction of Opening, Frank L. Fuller, Chairman, Boston; To Compile Information relating to Awards that have been made in Water Works Valuation Cases, H. W. Dean, Chairman, Boston; On Library, Charles W. Sherman, Chairman, Boston. An address was made by the retiring President George A. King, of Taunton, Mass., and reports received from other officers of the association. The following officers were elected for the ensuing year: President, Allen Hazen, New York; Vice-Presidents, J. Waldo Smith, Mem.Am.Soc. M.E., New York, Michael F. Collins, Lawrence, Mass., Leonard Metcalf, Mem.Am.Soc.M.E., Boston, Mass., Irving S. Wood, Providence, R. I., Frank A. McInnes, Boston, Mass., Morris Knowles, Mem. Am. Soc. M. E., Pittsburg; Secretary, Willard Kent, Narragansett Pier, R. I.; Treasurer, Lewis M. Bancroft, Reading, Mass., Editor, Richard K. Hale, Boston, Mass.

COURSE ON POWER AND PROPULSION AT POLYTECHNIC INSTITUTE

A course of lectures on the subject of Power and Propulsion will be given at the Brooklyn Polytechnic Institute by Prof. W. D. Ennis, Mem.Am.Soc.M.E.,

commencing February 1, and continuing through fourteen succeeding Wednesdays, at 6.30 p.m. The course is designed to show the physical principles underlying the determination of resistances to motion in the steam locomotive, the automobile, the aeroplane and the dirigible balloon, and to develop the leading factors involved in computation of power equipment.

BROOKLYN ENGINEERS CLUB

At a meeting of the Brooklyn Engineers Club, held at the Club House, Thursday evening, January 12, Henry P. Rust presented a paper upon the Hydro-Electric Power Plant of the Great Western Power Company, of San Francisco, Cal., on the North Fork of Feather River. This was illustrated by lantern slides. The location and characteristics of the river, the watershed and its possibilities, and the design and construction of the 55,000-h.p. hydro-electric plant at Big Bend were particularly dealt with.

Informal library talks were given on January 19, on the Lubrication of Cylinders, by R. C. Garhart; and on January 26 on the Reconstruction and Standardization of the Rolling Stock of the Brooklyn Rapid Transit Company, by W. G. Gove.

WISCONSIN ELECTRICAL ASSOCIATION

The annual convention of the Wisconsin Electrical Association was held on January 18 and 19 at the Hotel Pfister in Milwaukee, with papers and discussions on Publicity Campaigns, Some Principles established by the Wisconsin Railroad Commission; Electric Meter Testing; Ornamental Street Lighting; Insurance; Electric Railway Repair Shop Practice. Various social features added to the enjoyment of the meetings.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

The American Society of Heating and Ventilating Engineers held its 17th annual meeting in the Engineering Societies Building, New York, on January 24-26, 1911. At the business meeting held at its opening session on Tuesday afternoon, the following officers were elected: President, R. P. Bolton, Mem. Am.Soc.M.E.; 1st Vice-Presidents, John R. Allen, Mem.Am.Soc.M.E., S.R. Lewis; 2d Vice-Presidents, A. B.Franklin, Ralph Collamore; Secretary, Wm. M. Mackay; Treasurer, U. S. Scollay. On Wednesday evening the annual dinner was held at the New Grand Hotel. At the professional sessions, occupying both Wednesday and Thursday pretty fully, papers were read and discussed, including the Value of Good Ventilation, by Prof. Severance Burrage, of Purdue University; Standards of Ventilation, by Dr. W. A. Evans, of Chicago; Ventilation of the Capitol, Washington, D. C., by Nelson S. Thompson; Pipe Line Design for Central Station Heating, by B. T. Gifford, Mem.Am.Soc.M.E., Chicago. Topical discussions were also conducted upon Objections to the Making of Plans by Manufacturers for the Installation of their Apparatus; Use of Vacuum Systems in Heating Buildings; Smokeless Combustion in Steam Heating Plants; Reliable Data for Estimating the Radiation for Buildings of All

Classes; Value of Exhaust Steam as Compared with Live Steam for Heating Purposes; Desirability of having Ventilating Laws applied to Private Schools as well as Public Schools.

THE NATIONAL CIVIC FEDERATION

Delegates from all parts of the country, representing nearly every branch of industry, attended the eleventh annual meeting of The National Civic Federation, held in the Hotel Astor on January 12–14, 1911. President Seth Low of the Federation made his annual address and report upon the year's work at the opening session, and this was followed by a discussion upon the Regulation of Combinations and Trusts from the State and Federal standpoint. At the afternoon session Industrial Efficiency was presented including consideration of the piecework, bonus and premium systems of payment for labor. Among the speakers were Harrington Emerson, Mem.Am.Soc.M.E.; H. L. Gantt, Mem.Am.Soc. M.E.; Warren S. Stone; James O'Connell. The Need for Uniform State Legislation was presented in a symposium on Friday morning, on the subjects of Taxation, Banking, Insurance, Pure Food and Drugs, Reform in Legal Procedure, Regulation of Railways, Good Roads Building, Regulation of Corporations, and the Commercial Bills of the Uniform State Law Commissioners. Friday afternoon was devoted to a consideration of the Workmen's Compensation Act proposed by the Department of Compensation for Industrial Accidents and their Prevention, August Belmont, Chairman. This bill has been drawn up as the result of a year's careful work by the Legal Sub-Committee, P. Tecumseh Sherman, Chairman. In addition to members of the department, Col. Theodore Roosevelt, Andrew Carnegie, Hon. Mem.Am.Soc.M.E., John Mitchell and James Duncan, made addresses heartily advocating the bill.

The annual dinner of the Federation was given at the Hotel Astor on Friday evening, President Seth Low acting as toastmaster. Mediation and Arbitration of Industrial Disputes was discussed on Saturday morning.

SOCIETY OF AUTOMOBILE ENGINEERS

The Society of Automobile Engineers, which has within the last few months doubled its membership, held a largely attended annual meeting on January 11 and 12, 1911 in the assembly hall of the Automobile Club of America, New York City. At the business meeting on the first day of the convention, the following officers were elected: President, Henry Souther, Mem.Am.Soc.M.E.; Managers, Henry May, Howard Marmon, C.E. Davis, Mem.Am.Soc.M.E. Wednesday evening was occupied by a dinner and entertainment, with addresses by the retiring president, H. E. Coffin, Mem.Am.Soc.M.E., and the president-elect.

Four professional sessions were held, one Wednesday afternoon and the others on Thursday morning, afternoon and evening. A large number of papers were presented, including Electro Steel, by Joseph Schaeffers; Illustrations of Physical Facts relating to Metallurgy, by Radclyffe Furness; Construction of Highways for Motor Traffic, by Logan Waller Page; Leaf Springs, by E. K. Rowland; Novelties in Valve Systems, by E. P. Batzell; Hot Rolled Gears, by H. N. Sanderson; Commercial Gasoline and the Impurities that are being encountered, by F. H. Floyd; Test of a 20-h.p. Franklin Air-Cooled Motor, Prof. R. C.

Carpenter, Mem.Am.Soc.M.E.; Development of the Grinding Wheel, by Geo. N. Jeppson; Methods of Grinding, John C. Spence; Frictionless Friction Drive, Charles E. Duryea; Fire Protection Question, N. B. Pope; Automobile Contest Timing and Coaching, by Chester S. Ricker; Advantages of Long-Stroke Motors, E. A. Myers; Coöperation between the Electric Vehicle Manufacturer and the Central Station, Robert McA. Lloyd; The Ampere-Hour Meter for Electric Vehicles, by R. C. Lanphier; Gasoline-Electric Transmissions for Heavy Loads, by Alex. Churchward.

Reports of Committees on Standards were received: Iron and Steel Division, M. T. Lothrop, Mem.Am.Soc.M.E., Aluminum and Copper Alloys Division, Wm. H. Barr; Ball and Roller Bearings Division, D.F.Graham; Broaches Division, C. E. Davis, Mem.Am.Soc.M.E.; Carbureter Division, G. G. Behn; Gear Metals Constants Division, G. W. Sargent; Frame Sections Division, James H. Foster; Lock Washers Division, Frederick S. Sayre; Nomenclature Division, A. L. McMurtry; Seamless Steel Tubes Division, H. W. Alden, Mem.Am.Soc.M.E.; Sheet Metals Division, H. E. Coffin, Mem.Am.Soc.M.E.; Springs Division, A. C. Bergmann; Tire Efficiency Division, F. J. Newman; Miscellaneous Division, Henry Souther, Mem.Am.Soc.M.E.

As the society was in session during the National Automobile Exhibit at Madison Square Garden, and the exhibit of the American Motor Car Manufacturers at Grand Central Palace, the time of the members was most fully and profitably occupied.

INVENTORS' GUILD

Dissatisfaction with existing relations between the inventor and the patent law has led to the organization of the Inventor's Guild, the object of which is stated in its constitution as follows: "The object of the Guild is to advance the application of the useful arts and sciences, to further the interests and secure full acknowledgment and protection for the rights of inventors, to foster social relations among those who have made notable advances in the application of the useful arts and sciences." The membership of the guild is to be limited and is to include not only men who have made inventions, but who have achieved some measure of success therewith, and who will therefore be capable of exerting some influence.

The officers are: Ralph D. Mershon, Mem.Am.Soc.M.E., president; Chas. W. Hunt, Mem.Am.Soc.M.E., 1st vice-president; Chas. S. Bradley, 2d vice-president; Thomas Robins, secretary, and Henry L. Doherty, Mem. Am. Soc. M. E., treasurer.

THE SIBLEY GRADUATE CLUB

With the recent installation in the Department of Experimental Engineering Sibley College, Cornell University, of an organized branch of research, with Prof. R. C. Carpenter, Mem.Am.Soc.M.E., at the head, a new stimulus has been given to experimental research work. This has been still further augmented by the formation of a Sibley Graduate Club, composed of all advanced and graduate students taking work in Sibley College, to promote and encourage original investigation among the graduate students.

The officers of the club are: President, T .C. Ulbricht, Jun.Am.Soc.M.E.; Vice-President, A. G. Bierma; Secretary and Treasurer, C. A. Carpenter.

PERSONALS

C. E. Ard, formerly located at Starkville, Miss., has been appointed professor of mechanical engineering of the Mississippi Agricultural and Mechanical College, Agricultural College, Miss.

Frank G. Bolles has become identified with the Reliance Engineering & Equipment Co., Milwaukee, Wis. Until recently he was in the employ of the Allis-Chalmers Co., of the same city.

W. Van Alan Clark, recently associated with the Astoria Light, Heat & Power Co., Astoria, L. I., N. Y., has become affiliated with the Consolidated Gas Co., as assistant superintendent of the 99th St. Works, New York.

T. B. Davis has severed his connection as chief engineer of the Cleveland Crane & Engineering Co., Wickliffe, O., to accept the position of president and general manager of the Arkansas Farms Co., Little Rock, Ark.

Wm. J. Edwards has become connected with the Binghamton Clothing Co., Binghamton, N. Y., in the capacity of vice-president and treasurer. Mr. Edwards was formerly in the employ of the Tide Water Oil Co.

Harry Gay, formerly associated with A. L. Drum & Co., Chicago, Ill., has become connected with the Stone & Webster Engineering Corp., Boston, Mass.

W. E. Gray has sold his interests in the Skaneateles Paper Co., Skaneateles, N. Y., and is now general sales manager of The Enameled Pipe & Engineering Co., Elyria, O.

Charles A. Francis has become identified with the National Printing Machinery Co., Inc., Athol, Mass., as manufacturing superintendent.

George Hanson, formerly superintendent of the Charter Gas Engine Co., Sterling, Ill., has become president and general manager of the Havana Manufacturing Co., Havana, Ill.

W. E. Lindsay, consulting engineer, formerly located at Birmingham, Ala., has assumed the position of secretary and treasurer of the American Welding Co., Carbondale, Pa.

W. L'E. Mahon has become associated with the Titan Steel Casting Co., Newark, N. J. He was recently identified with the Taylor Iron & Steel Co., New York.

R. S. de Mitkiewicz, lately associated with the Alden Sampson Manufacturing Co., has become affiliated with the Motors Engineering & Sales Co., of New York, in the capacity of power sales engineer.

John I. Rogers, formerly associated with the Midvale Steel Co., Philadelphia, Pa., has opened a New York office for the practice of consultation and design.

William H. Smead, formerly employed as engineer with the General Fire Extinguisher Co., has been promoted to engineer of the Western heating and power piping department of the same company, with headquarters at Warren, O.

C. N. Thorn has resigned the position of assistant manager of the machinery department of Manning, Maxwell & Moore, Inc., New York, to accept the position of purchasing agent and mechanical engineer with Hugh, Kelly & Co., New York.

Wm. B. Updegraff has entered the employ of the Architectural Tile & Faience Co., Maurer, N. J. He was formerly associated with the Harlem Contracting Co., New York.

Thos. J. Walsh, who has been connected with the Stone & Webster Engineering Corp., Boston, Mass., as engineer, has opened an office in Boston, Mass., with the examining, estimating and designing for electric and manufacturing plants as his specialty.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society, included in the Engineering Library. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

AMERICAN RAILWAY ASSOCIATION. Proceedings. St. Louis, November 1910. Gift of Association.

BRITISH ASSOCIATION OF GAS MANAGERS. Proceedings. 1880, 1881. *London, 1880, 1881.*

CONSTRUCTION AND WORKING OF INTERNAL COMBUSTION ENGINES. By R. E. Mathot. Translated from the French by W. A. Tookey. *New York, D. Van Nostrand Co., 1910.* Gift of author.

ELECTRICAL ENGINEERS' POCKET BOOK, 1911. Eleventh annual edition. Edited by W. H. Fowler. *Manchester, Scientific Pub. Co.* Gift of publishers.

ELEMENTS OF GRAPHIC STATICS AND OF GENERAL GRAPHIC METHODS. By W. L. Cathcart and J. I. Chaffee. *New York, D. Van Nostrand Co., 1910.* Gift of publishers.

FALL RIVER RESERVOIR COMMISSION. Report upon Improvement of the Quequechan River, 1910. *Lowell, 1910.* Gift of Arthur T. Safford.

GAS INSTITUTE. Transactions. 1882, 1883, 1886–1890. *London, 1882–1890.*

HOISTING AND CONVEYING MACHINERY. Compiled by Paul Stülpnagel. Deinhardt-Schlomann Series of Technical Dictionaries in Six Languages, vol. 7. *London, Constable & Co., Ltd., 1910.*

INDIA RUBBER AND ITS MANUFACTURE. By H. L. Terry. *New York, D. Van Nostrand Co., 1907.*

INFLUENCE OF MECHANICAL DRAFT UPON THE ULTIMATE EFFICIENCY OF STEAM BOILERS. By W. B. Snow. Reprinted from the Columbia Engineer, Columbia University. Gift of B. F. Sturtevant Co.

INTERNAL COMBUSTION ENGINE. By H. E. Wimperis. *New York, D. Van Nostrand Co., 1908.*

IRON AND STEEL. A pocket encyclopedia, including Allied Industries and Sciences. By H. P. Tiemann. With an introduction by H. M. Howe. *New York, McGraw-Hill Book Co., 1910.* Gift of publishers.

LELAND STANFORD JUNIOR UNIVERSITY. Alumni Directory and Ten-Year Book, vol. 2, 1891–1910. *Stanford University, 1910.*

LONG DISTANCE TRANSMISSION OF STEAM AND ITS EFFECT ON POWER PLANT ECONOMICS. Univ. of Wisconsin Engineering Service Bulletin, vol. 6. no. 3. By H. J. Thorkelson. *Madison, 1910.* Gift of C. W. Rice.

MECHANICAL DRAFT. A Practical Treatise. Edited by W. B. Snow. *Boston, B. F. Sturtevant Co.* Gift of B. F. Sturtevant Co.

MECHANICAL ENGINEERS' POCKET BOOK, 1911. Thirteenth annual edition. Edited by W. H. Fowler. *Manchester, Scientific Pub. Co.* Gift of publisher.

Mechanical Ventilation and Heating by a Forced Circulation of Warm Air. By W. B. Snow. *Boston, B. F. Sturtevant Co.* Gift of B. F. Sturtevant Co.

Mechanics' and Machinists' Pocket Book and Diary, 1911. Edited by W. H. Fowler. *Manchester, Scientific Pub. Co.* Gift of publishers.

New York City Board of Estimate and Apportionment. Communication from F. J. Sprague. Gift of C. W. Rice.

New York State Library. 24th Annual Report of the New York State Library School, 1910. *Albany, 1910.*

Paper Technology. An Elementary Manual. ed. 2. By R. W. Sindall. *London, Chas. Griffin & Co., 1910.*

Pennsylvania State College, School of Engineering. Announcement, 1910–1911. *State College, 1910.* Gift of the college.

Physical Significance of Entropy or of the Second Law. By J. F. Klein. *New York, D. Van Nostrand Co., 1910.* Gift of author.

Reinforced Concrete in Sub- and Superstructure. Compiled by Heinrich Becher. Deinhardt-Schlomann Series of Technical Dictionaries in Six Languages, vol. 8. *London, Constable & Co., Ltd., 1910.*

Traveling Engineers' Association. Proceedings of the 18th Annual Convention, 1910. *Buffalo, 1910.*

U. S. Light House Board. Annual Report of the Operations. 1910. *Washington, 1910.* Gift of Light House Board.

Ventilation in its Relation to Health. By W. G. Snow. Gift of Warren Webster & Co.

Webb's Academy and Home for Shipbuilders. Annual Report, 1910. *New York, 1910.* Gift of the Academy.

GIFT OF MRS. F. B. HALL

Applied Mechanics. By G. Lanza. *New York, 1886.*

Architects and Builders' Pocketbook. By F. E. Kidder. ed. 13. *New York, 1902.*

Building Estimator. By Wm. Arthur. *1904.*

Building Superintendence. By T. M. Clark. ed. 8. *Boston, 1890.*

Carnegie Steel Company. Pocket Companion, 1903. *Pittsburg, 1903.*

Crane Company Complete Pocket Catalogue, Steam Goods, etc. August 1902. *Chicago, 1902.*

Electrical Catechism. By A. J. DuBois. *New York, 1902.*

Elements of the Differential and Integral Calculus, with Examples and Applications. By J. M. Taylor. *Boston, 1886.*

Elements of Machine Design. By W. C. Unwin. ed. 10. *London, 1888.*

Gas Engine. By Dugald Clerk. ed. 2. *New York, 1887.*

Hydraulics and Hydraulic Motors. By A. J. DuBois. *New York, 1889.*

Indicator Practice and Steam Engine Economy. By F. F. Hemenway. ed. 2. *New York, 1888.*

International Correspondence School. Electrical Engineers' Pocketbook. *Scranton, 1908.*

——Mechanics' Pocket Memoranda. ed. 6. *Scranton, 1903.*

——Telephone and Telegraph Engineers' Pocketbook. *Scranton, 1908.*

Manual of Mechanics of Engineering. By P. J. Weisbach. *New York, 1889.*

NATIONAL TUBE COMPANY. Book of standards and useful information containing tables of sizes and other useful information pertaining to tubular goods. *Pittsburgh, 1902.*

PRACTICAL TEXT BOOK ON PLANE AND SPHERICAL TRIGONOMETRY. By Webster Wells. *Boston, 1883.*

STRAINS OF FRAMED STRUCTURES. By A. J. DuBois. ed. 9. *New York, 1892.*

TABLES OF THE PROPERTIES OF SATURATED STEAM AND OTHER VAPORS. By C. H. Peabody. *New York, 1888.*

THEORY OF STRUCTURES AND STRENGTH OF MATERIALS. By H. T. Bovey. ed. 3. *New York, 1900.*

THERMODYNAMICS OF THE STEAM ENGINE AND OTHER HEAT ENGINES. By C. H. Peabody. *New York, 1889.*

TREATISE ON ELEMENTARY GEOMETRY. By Wm. Chauvenet. *Philadelphia, 1885.*

TREATISE ON MASONRY CONSTRUCTION. By I. O. Baker. ed. 3. *New York, 1890.*

EXCHANGES

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION. Report of the Proceedings of the 43d Annual Convention. 1910. *Chicago, 1910.*

ECOLE D'APPLICATION DU GÉNIE MARITIME. Cours d'Electricité. *1907–1908.*

INSTITUTION OF MECHANICAL ENGINEERS. Brief Subject Index of Papers Published in the Proceedings. *1847–July 1910.*

LIVERPOOL ENGINEERING SOCIETY. Transactions. vol. 31. *Liverpool, 1910.*

U. S. NAVAL OBSERVATORY. Synopsis of the Report of the Superintendent of the United States Naval Observatory. 1910. *Washington, 1910.*

UNIVERSITY OF ILLINOIS ENGINEERING EXPERIMENT STATION BULLETIN. vol. 4–5. *Urbana, 1909, 1910.*

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

060 Assistant engineer for water works plant. Technical graduate preferred, good knowledge of steam engineering and operation of boiler plants. Location Indiana.

061 Designer of heavy duty marine engines. Well established marine engineering department building engines for pleasure purposes. Man desired should be able to guide not only along mechanical lines in respect to the heavy duty engines, but be safe man from commercial standpoint. Location Michigan.

062 Assistant to manufacturing superintendent. Concern employing 1200 to 1400 men on varied lines. Loyal, energetic and tactful manufacturing man. Location Michigan.

063 Large manufacturing company in Philadelphia, first-class salesman familiar with commercial and mechanical end of selling electric trucks. State age, experience, and references, also salary expected.

064 Steam engineer, power house and sub-station work of large railway. Salary between $200 and $250 per month. Location New York.

065 Chief engineer; power department Cement Company totalling about 4000 h.p., 75 per cent gas engine operating on natural gas. Will pay $2000 a year salary to start. Location Kansas.

066 Man to work through factory improving manufacturing methods and factory organization. Would prefer one who has spent year or two in shops in direct contact with manufacturing or cost keeping. Pay at the start $1000. Location Canada.

067 Man to take charge of the manufacturing of small Canadian factory, with executive as well as manufacturing experience. Pay at the start $1200 to $1500. Manufacture of all kinds of spoons, forks, knives, pitchers, etc.

068 Engineer having knowledge of process of manufacturing carborundum. competent to superintend the construction and operation of plant. Salary commensurate with responsibilities of position. Location Rhode Island.

069 Assistant superintendent, good organizer, must know how to handle men properly and be able to produce work of the best quality at lowest cost. Prefer man thoroughly acquainted with cotton mill machinery and what machinery has to do in the mills. Location Massachusetts.

070 Engineer on design, estimating and sale of punching and shearing machinery, air compressors, etc. Location Michigan.

MEN AVAILABLE

161 Member, experienced in hydro and steam electric plant design and operation, desires position as designing engineer or superintendent. Thorough technical education; twelve years experience. At present employed. Best of references.

162 Junior, twenty-six. Graduate Mass. Inst. Tech., three years in Far East as manager for machinery importing house; desires position in sales department of large manufacturing concern, especially familiar with machine tool lines; had unlimited responsibility in executive position.

163 Stevens graduate, long experience in design, construction and management of manufacturing plants, patents, cost system, purchasing; specially interested in economics, organization and reduction of costs, from boiler room to finished product. Desires position in executive capacity, with new business or one needing reorganizing; would invest in the undertaking.

164 Engineer, works manager, designer and salesman, broad acquaintance in New York City and elsewhere, would like to form partnership with two congenial men or established firm of engineers. Can take leading part in business getting or in practical engineering work, in systematizing and management for results. Can work in accordance with system or principles of head of firm or independently.

165 Member, graduate in mechanical engineering; twelve years experience, seven years with Eastern institution, design and supervision of lighting, heating, ventilating and power plant installations; desires position with consulting engineer or architect. Salary $2400.

166 Junior member, married, technical graduate in mechanical engineering and manual training, four years experience in special work of large industrial plant. Experience would be of benefit in almost any line.

167 Technical graduate desires position as chief draftsman or engineer, experience in steam engineering, gas producer design and operation, fuel and gas analysis. Location New York or vicinity.

168 Graduate mechanical and metallurgical engineer, desires connection as consulting or chief engineer with company engaged in extensive development, exploitation and operation of mining properties or metallurgical processes. Wide experience in United States, Canada, Mexico and Europe. Especially qualified to determine or develop methods for ore treatment with particular regard for economic features. Design complete reduction works, power accessories and transportation facilities and supervise construction and management of same.

169 Electrical and mechanical engineer, eighteen years varied experience in electrical construction, steam and electrical power plant equipment, operation and repairs, ice-making and refrigerating engineering and construction. Good organizer and executive; desires position as general manager or chief engineer.

170 Member, desires position as general superintendent, representative, or consulting engineer in Boston or other New England manufacturing concern, devoting all or part of time.

171 Stevens Institute M.E., 1900, past ten years associated with large electrical manufacturing concern, extensive experience in factory management embracing cost reduction, production, etc., cost systems and selling. Engaged at present but wishes to locate in New York city or vicinity as works or office manager.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ARD, Charles Edgar (1908), Prof. Mech. Engrg., Miss. A. & M. College, Agricultural College, Miss.

AUTENRIETH, George C. (Junior, 1908), Instr., Descriptive Geometry and Drawing, College of the City of N.Y., New York, N. Y., and *for mail*, 55 Second St., Weehawken, N. J.

BAKER, Chalice Whitmore (1905), Mech. Engr., Allis-Chalmers Co., and *for mail*, 273 Howell Ave., Milwaukee, Wis.

BEECHER, J. F. (Associate, 1908), Checker, Indiana Steel Co., and *for mail*, 660 Adams St., Gary, Ind.

BENNETT, Geo. G. (Junior, 1903), Engrg. Dept., Am. Thread Co., 549 Main St., and *for mail*, 433 Elm St., Holyoke, Mass.

BIRKINBINE, John (1888), Cons. Engr., Parkway Bldg., Broad and Cherry Sts., Philadelphia, and *for mail*, Cynwyd, Montgomery Co., Pa.

BLAKESLEE, Frank Arthur (1910), Mech. Supt., Taquah Min. & Exploration Co., Tarkwa, Gold Coast Colony, West Africa, and 1233 Prospect Ave., Kansas City, Mo.

BOLLES, Frank G. (Associate, 1901), Reliance Engrg. & Equip. Co., Engrg. Bldg., Milwaukee, Wis.

BUCK, Irwin (Junior, 1907), Mgr., Alcohol Utilities Co., 156 W. 23d St., and *for mail*, 342 W. 56th St., New York, N. Y.

CARPENTER, Alfonso H. (Associate, 1895), Westlake Hotel, 720 Westlake Ave., Los Angeles, Cal.

CHAMBERS, Norman C. (Junior, 1905), Export Dept., Niles-Bement-Pond Co., 111 Broadway, New York, N. Y.

CLARK, W. Van Alan (Junior, 1910), Asst. Supt., 99th St. Wks., Consltd. Gas Co., 99th St. and 2d Ave., New York, N. Y.

CLERGUE, Bertrand J. (Associate, 1907), Cons. Engr., Rm. 711, 90 West St., New York, N. Y.

COWARD, Herbert (Junior, 1905), Coward & Long, Peoples Bank Bldg., Wilkes-Barre, and 28 Philadelphia Ave., West Pittston, Pa.

DAVIS, Thomas B. (1907; 1909), Pres. and Genl. Mgr., Arkansas Farms Co., 804 State Bank Bldg., Little Rock, Ark.

DICKINSON, William Noble (1906), Mgr., Foreign Dept., Otis Elev. Co., 17 Battery Pl., New York, and 38 De Koven Court, Brooklyn, N. Y.

DIRKS, Henry B. (Junior, 1907), 3811 N. Seeley Ave., Chicago, Ill.

ELLENBOGEN, Sidney Arthur (Junior, 1910), Manhattan Shirt Co., 207 River St., and *for mail*, 635 Broadway, Paterson, N. J.

ELLIOTT, Elmer G. (1907), J. G. White & Co., Inc., Engrs., Contrs., Alaska Commer. Bldg., San Francisco, and *for mail*, 1063 Oak St., Oakland, Cal.

EVANS, William Francis (1897), Mech. and Production Engr., Deere & Co., and *for mail*, 2001 Seventh Ave., Moline, Ill.

FRANCIS, Charles A. (Associate, 1906), Mfg. Supt., Natl. Ptg. Mchy. Co., Inc., 167 Hapgood St., and *for mail*, P. O. Box 979, Athol, Mass.

GAY, Harry (Associate, 1907), Stone & Webster Engrg. Corp., 147 Milk St., Boston, Mass.

HOLMAN, R. Claude (1907), Ch. Engr., Hooven-Owens-Rentschler Co., Hamilton, O.

JOHNSON, Bradley S. (Associate, 1909), Rep., The T. H. Symington Co., Maryland Trust Bldg., and *for mail*, 2938 Clifton Ave., Baltimore, Md.

LAWRENCE, Howard F. (Junior, 1908), Am. Ship Windlass Co., and *for mail*, 111 Abbott St., Providence, R. I.

LELAND, William Emmons (1904), Cons. Engr., 832 Merchants Exch., San Francisco, and Berkeley, Cal.

LINDSAY, W. Edward (1895), Secy. and Treas., Am. Welding Co., and 31 Garfield Ave., Carbondale, Pa.

LONGWELL, Henry E. (1901), Cons. Engr., Westinghouse Mch. Co., East Pittsburg, and 206 N. Homewood Ave., Pittsburg, Pa.

McJILTON, John Perkins (Junior, 1910), Draftsman, Superheater Dept., Am. Loco. Co., and *for mail*, Box 384, Schenectady, N. Y.

McMULLIN, Frank V. (1903), 5805 Master St., Philadelphia, Pa.

MAHON, Wm. L'E. (1889), Titan Steel Casting Co., Newark, N. J., and 610 Church St., Ann Arbor, Mich.

MANTON, Arthur Woodroffe (1908), Civ. and Mech. Engr., 10 Victoria St., Westminster, London, and Ellerburn, Woodbourne Rd., Edgbaston, Birmingham, England.

MAYHEW, Ray (Associate, 1910), Asst. Ch. Draftsman, Mech. Dept., Minneapolis Steel & Mchy. Co., and *for mail*, 2800 17th Ave., S., Minneapolis, Minn.

MOON, Hartley Allen (Associate, 1908), in Charge of Drafting and Test Depts., Continental Gin Co., and 1703 14th Ave., S., Birmingham, Ala.

MURRIE, John L. (Junior, 1905), Ford, Bacon & Davis, 115 Broadway, New York, N. Y., and *for mail*, care Consltd. Gas Elec. Light & Power Co., Lexington and Liberty Sts., Baltimore, Md.

NICHOLL, John Seymour (Junior, 1909), 144 Columbia Hgts., Brooklyn, N. Y.

ORD, Henry C. (1905), Bath, Me.

POTTER, Wm. Bleecker (1895), Mgr. and Ch. Engr., St. Louis Sampling & Testing Wks., 713 Clark Ave., and 4021 Washington Blvd., St. Louis, Mo.

RANSOM, Allan (Associate, 1903), 237 Canyon Drive, Hollywood, Los Angeles, Cal.

RICHARDS, Francis H. (1880), Life Member; Mech. Engr., Pat. Atty., 9–15 Murray St., New York, N. Y., and *for mail*, 112 Edwards St., Hartford, Conn.

ROBINSON, Henry Smith (1896), Cons. Engr. and Pres., Atlantic Wks., 28 State St., Boston, and 97 Main St., Andover, Mass.

SHERMAN, C. K. (Associate, 1902), West. Rep., Under Feed Stoker Co. of Am., 714 Long Bldg., Kansas City, Mo.

SMITH, Geo. Marshall (Associate, 1904), V. P. and Treas., A. E. Anderson & Co., 28 Builders Exch., Buffalo, N. Y., and 4632 N. Winchester Ave., Chicago, Ill.

SOPER, Ellis (1905; Associate, 1908), Pres., The Soper Engrg. Co., 628 Ford Bldg., and 116 Gladstone Ave., Detroit, Mich.

TREGELLES, Henry (1888), Bartolmé Mitre 544, Buenos Aires, and Hurlingham F. C. Pacifico, Buenos Aires, Argentine Repub., S. A.

TURNER, Charles H. (Junior, 1905), P. O. Box 645, Worcester, Mass.

UPDEGRAFF, William Barrett (1910), Architectural Tile & Faience Co., Maurer, and 522 Magie St., Elizabeth, N. J.

WILSON, Jacob D. (Junior, 1903), Pres., Genl. Mgr. and Mech. Engr., Am. Elev. Co., 113-115 Cedar St., New York, N. Y., and *for mail*, 215 Essex Ave., Boonton, N. J.

YOUNG, E. R. (Junior, 1900), Biddle and West Sts., Wilkinsburg, Pa.

YOUNG, Gilbert A. (1906), Assoc. Prof. Engrg., Purdue Univ., and *for mail*, 409 Harrison St., West Lafayette, Ind.

NEW MEMBERS

BENTLEY, Oliver D. H. (1910), Turbine Dept., B. F. Sturtevant Co., Hyde Park, Mass.

CARDULLO, Forrest Ellwood (1910), Prof. Mech. Engrg., New Hampshire College, Durham, N. H.

MURRAY, Warren Edwards (1910), Ch. Engr., West. Sugar Refining Co., and *for mail*, 132 Grattan St., San Francisco, Cal.

NOTT, Albin James (Junior, 1910), Switchboardman in Charge Pumping Sta. No. 6, Sewerage and Water Bd., and *for mail*, 4122 Perrier St., New Orleans, La.

PROMOTIONS

TAFT, Theodore Howard (1903; 1910), Asst. Prof. Mech. Engrg., Mass. Inst. of Tech., Boston, and *for mail*, 1 Avon Pl., Cambridge, Mass.

VOSE, Fred Hale (1906; 1910), Asst. Prof. Mech. Engrg., Case Sch. of Applied Science, and *for mail*, 10,521 Lee Ave., N. E., Cleveland, O.

WHITTEMORE, Herbert L. (1903; 1910), Engr. of Tests, Watertown Arsenal, Watertown, Mass.

DEATHS

HENNING, Gustavus C., December 30, 1910.

PIERCE, Walter L., December 10,1910.

GAS POWER SECTION

CHANGES OF ADDRESS

CORMACK, Geo., Jr., (Affiliate, 1908), Supt., Gas Eng. Dept., Independent Harvester Co., Plano, Ill.

DAVIDSON, T. C. (Affiliate, 1909), Erector, 429 27th Ave., Milwaukee, Wis.

KNOTT, Henderson W. (Affiliate, 1908), 114 Liberty St., New York, N. Y.

LATHROP, Jay Cowden (Affiliate, 1908), care Wm. Fargo, Jackson, Mich.

LUCKETT, Gustavus Tyler (Affiliate, 1908), Mgr., Piping Dept., M. W. Kellogg Co., 50 Church St., New York, N. Y.

McMULLIN, Frank V. (1908), Mem.Am.Soc.M.E.

de MITKIEWICZ, R. S. (Affiliate, 1908), Power Sales Engr., Motors Engrg. & Sales Co., 250 W. 54th St., and *for mail,* 117 W. 58th St., New York, N. Y.

STUDENT BRANCHES

CHANGES OF ADDRESS

BAILEY, Raymond W. (Student, 1910), Phi Tau House, State College, Pa.
BESS, Earl (Student, 1910), Y.M.C.A., Denver, Colo.
HAYNES, H. Hasbrouck (Student, 1909), 84 Fulton St., New York, N. Y.
HEIBEL, Walter E. (Student, 1910), 414 Main Bldg., State College, Pa.
HERRMANN, George A. (Student, 1909), 6443 Jefferson Ave., Second Flat, Chicago, Ill.
LINLEY, Fred. H. (Student, 1910), 190 27th St., Milwaukee, Wis.
MINICH, Jay A. (Student, 1910), Delphi House, State College, Pa.
PAGE, Atwood C. (Student, 1909), present address unknown.
PARSONS, H. N. (Student, 1909), 41 W. 33d St., Chicago, Ill.
PERHAM, D. E. (Student, 1910), 312 Main Bldg., State College, Pa.
ROMIG, F. G. (Student, 1910), 636 Adams St., Gary, Ind.
SPERRY, F. E. (Student, 1909), 404 Kane St., Aurora, Ill.
STEED, Arthur (Student, 1910), 511 Jeannette St., Wilkinsburg, Pa.
WILLIAMS, Nezza N. (Student, 1910), 235 McAllister Hall, State College, Pa.

COMING MEETINGS

FEBRUARY—MARCH

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

February 10, monthly meeting, 29 W. 39th St., New York. February 14–16, Mid-Year Convention, Pittsfield, Mass., and Schenectady, N. Y. Papers: Mechanical Forces in Magnetic Fields, C. P. Steinmetz, Mem.Am. Soc.M.E.; Problems in the Operation of Transformers, F. C. Green; Protection of Electric Transmission Lines, E. F. C. Creighton; Test of Grounded Phase Protector on the 44,000-Volt System of the Southern Power Company, C. I. Burkholder and R. H. Marvin; Tests of Losses of High Tension Lines, G. Facciolo; The Temperature Gradient in Oil-Immersed Transformers, James Murray Weed; Hysterises and Eddy Current Exponents for Silicon Steel, W. J. Woodbridge; Commercial Problems of Transformer Design, R. H. Wilson; Design, Construction and Test of an Artificial Transmission Line, J. H. Cunningham. Secy., R. W. Pope, 29 W. 39th St., New York.

AMERICAN INSTITUTE OF MINING ENGINEERS

February 21, annual business meeting, 29 W. 39th St., New York, Secy., Dr. Joseph Struthers.

AMERICAN SOCIETY OF CIVIL ENGINEERS

February 1, 15, bi-monthly meetings, 220 W. 57th St., New York. Secy., C. W. Hunt.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

February 14, 29 W. 39th St., New York. February 17, Boston, Mass. Secy. Calvin W. Rice.

ASSOCIATION OF ONTARIO LAND SURVEYORS

February 28, annual meeting, Parliament Bldgs., Toronto, Canada. Secy., Killaly Gamble, 704 Temple Bldg.

BOSTON SOCIETY OF CIVIL ENGINEERS

February 15, Boston, Mass. Paper: Water Resources of the State of New York, Walter McCulloh. March 15, annual meeting, Boston City Club. Secy., S. Everett Tinkham, 715 Tremont Bldg.

CANADIAN MINING INSTITUTE

March 2–4, annual meeting, Quebec, Canada. Secy., H. Mortimer-Lamb. Rms. 3–4 Windsor Hotel, Montreal.

ENGINEERS' CLUB OF PHILADELPHIA
February 4, annual meeting, 1317 Spruce St. Secy., W. P. Taylor.

IOWA ENGINEERING SOCIETY
February 14, 15, 16, annual meeting, Des Moines. Secy., S. M. Woodward, Iowa City.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION
February 6–11, annual convention, Louisville, Ky. Secy., T. A. Randall, Indianapolis, Ind.

NEBRASKA CEMENT USERS ASSOCIATION
February 1–3, annual convention, Omaha. Secy., Peter Palmer, Oakland.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS
February 15, annual meeting, Boston, Mass. Secy., N. W. Gifford, 26 Central Sq., East Boston.

NEW ENGLAND STREET RAILWAY CLUB
March 23, annual meeting, Boston, Mass. Secy., John J. Lane, 12 Pearl St.

NEW ENGLAND RAILROAD CLUB
February 14, New American House, Boston, Mass. Paper: Impressions of English Railway Service, W. J. Cunningham. Secy., Geo. H. Frazier, 10 Oliver St.

RAILWAY SIGNAL ASSOCIATION
March 20, Stated Meeting, Congress Hotel, Chicago, Ill. Paper: Alternating Current Signaling. Secy., C. C. Rosenberg, Bethlehem, Pa.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
February			
1	Wireless Institute	S. L. Williams	8.00 p.m.
2	Blue Room Engineering Society	W. D. Sprague	8.15 p.m.
9	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
10	American Institute Electrical Engineers	R. W. Pope	8.15 p.m.
14	American Society Mechanical Engineers	C. W. Rice	8.15 p.m.
17	New York Railroad Club	H. D. Vought	8.15 p.m.
21	New York Telephone Society	T. H. Lawrence	8.15 p.m.
22	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
March			
2	Blue Room Engineering Society	W. D. Sprague	8.15 p.m.
9	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
10	American Institute Electrical Engineers	R. W. Pope	8.15 p.m.
17	New York Railroad Club	H. D. Vought	8.15 p.m.
21	New York Telephone Society	T. H. Lawrence	8.15 p.m.
22	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.

CURRENT BOOKS

THE CONSTRUCTION AND WORKING OF INTERNAL COMBUSTION ENGINES. A Practical Treatise upon Methods of Construction, with Calculations for the Use of Engineers, Manufacturers, and Users, and a Critical Study of Present-day Types. By R. E. Mathot. *New York, D. Van Nostrand Co. 1910.* Cloth, 8vo, 554 pp., illustrated. Price, $5.

Contents: The Progress of Gas Power; Gas Versus Steam Engines; The Future of Gas Power; Principal Types of Gas Engines; Horizontal Gas Engines; Vertical Gas Engines; Marine Gas Engines; Two-Cycle Engines; Four-Cycle Engines; The Working of Gas Engines; Governing and Valve Gears; Details of Construction; Moving Parts; Testing and Testing Apparatus; Indicator Diagrams; Dimensions, Classifications, and Tests of Engines; Bibliography; Gas Engine and Gas Producer Makers; Device for Controlling Speed of Internal Conbustion Engines.

IRON AND STEEL. A Pocket Encyclopedia. Including Allied Industries and Sciences. By Hugh P. Tiemann. *New York, McGraw-Hill Book Co., 1910.* Leather, 12mo, 354 pp., illustrated. Price, $3.

PHYSICAL SIGNIFICANCE OF ENTROPY OR OF THE SECOND LAW. By J. F. Klein. *New York, D. Van Nostrand Co., 1910.* Cloth, 8vo, 98 pp. Price, $1.50 net.

Contents: Definitions, General Preliminary, Development, Current and Precise Statements of the Matters Considered; Analytical Expressions for a Few Primary Relations; The Physical Interpretations; Summary of the Connection between Probability, Irreversibility, Entropy, and the Second Law.

THE ELEMENTS OF GRAPHIC STATICS and of General Graphic Methods. By William Ledyard Cathcart and J. Irvin Chaffee. *New York, D. Van Nostrand Co. 1910.* Cloth, 8vo, 311 pp., 159 illustrations. Price, $3 net.

Contents: Graphic Arithmetic; Graphic Measurement of Areas; Forces: Concurrent, Non-concurrent, Non-parallel; Parallel Forces; Couples, Centre of Gravity; Moments; The Fundamental Theory of Beams; Framed Structures; Roof Trusses, Braced Cantilevers; Bridge Trusses; The Graphics of Friction; Moment Diagrams for Friction.

FOWLER'S ELECTRICAL ENGINEER'S POCKET BOOK, 1911. Edited by William H. Fowler. 11th annual edition. *Manchester, Scientific Pub. Co., 1911.* Cloth, pocket book size, 574 pp. Price, 1s., 6d.

Contents: Miscellaneous Tables, etc.; Wire Tables; Magnetism and Magnetic Data; Conductors and Insulating Materials; Electric Lighting and Wiring; Comparison and Measurement of Resistances; Electrical Measuring Instruments; Electricity Meters; Primary and Secondary Batteries; Dynamos and Motors; Alternate Electric Currents; Alternators; Transformers; Alternate Current Motors; Switchboards, Circuit Breakers, and Lightning Arresters; Electrical Power Transmission and Distribution; Rotary Converters; Electric Traction; Rules and Regulations.

Fowler's Mechanical Engineers' Pocket Book, 1911. Edited by William H. Fowler. 13th annual edition. *Manchester, Scientific Pub. Co., 1911.* Cloth, pocket book size, 653 pp. Price, 1s., 6d.

Contents: Miscellaneous Tables and Formulae; Steam Boilers and Fittings; Fuels and Combustion; Steam Engines; Steam Turbines; Locomotives; Steam Tables; Valves and Valve Gear; Gas Engines; Gases used in Gas Engines; Oil Engines; Hydraulics; Pumps and Pumping Arrangements; Gearing and Lubrication; Hoisting and Lifting Machinery; Mining Machinery and Appliances; Metallurgy of Iron and Steel; Strength of Metals and Alloys; Beams and Pillars; Springs; Chemistry; Ventilation and Heating.

Fowler's Mechanics' and Machinists' Pocket Book and Diary, 1911. Edited by William H. Fowler. *Manchester, Scientific Pub. Co., 1911.* Cloth, pocket book size, 456 pp. Price, 6d.

Contents: Handy References and Tables; Mensuration, Geometry and Trigonometry; Uses of Logarithms and Antilogarithms; Materials used in Machine Construction; Machine Tool Design; Proportions of Machine Tool Parts; Metal Cutting Tools; High Speed Tool Steels; Drilling and Boring Metal; Screw Threads, Screw Cutting and Taper Turning; Emery and Emery Wheels; Shop Practice; Wheel Gearing; Belt and Rope Driving; Shafting and Bearings; Lifting Ropes and Chains.

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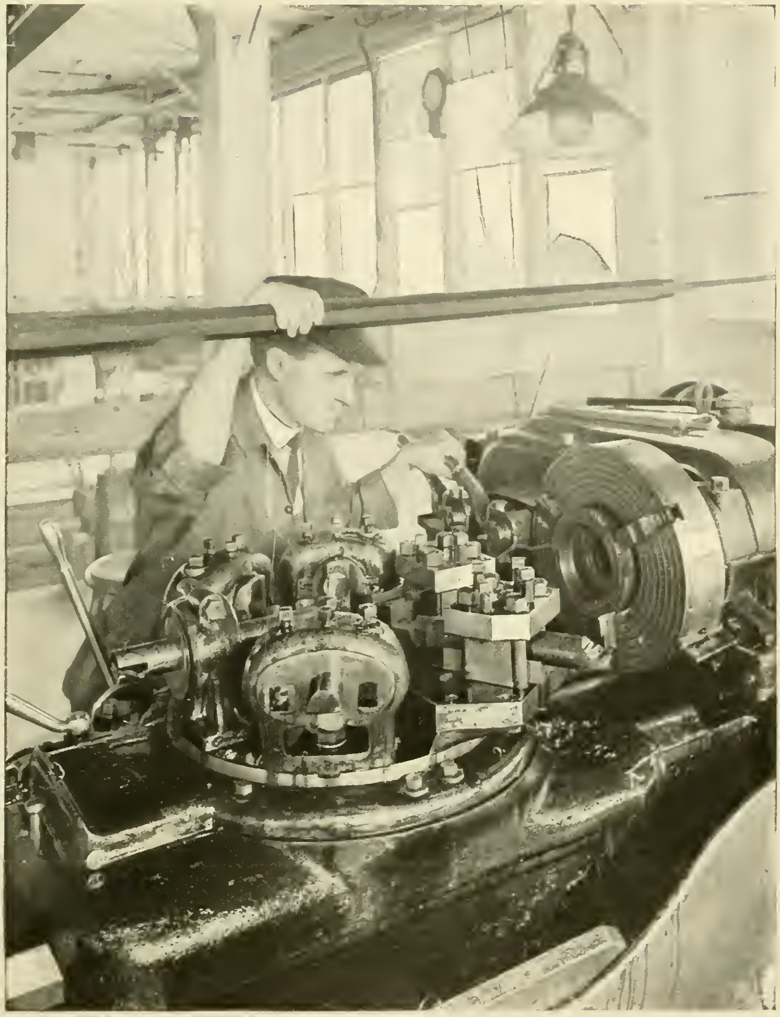

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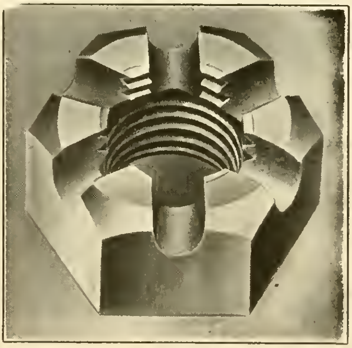

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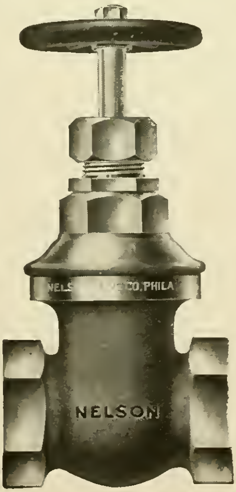

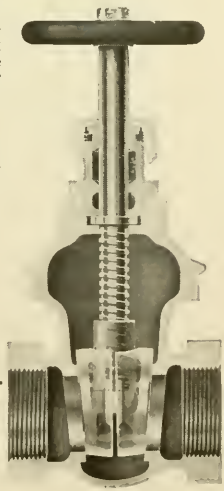

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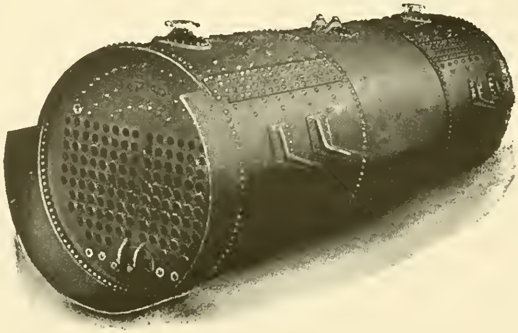

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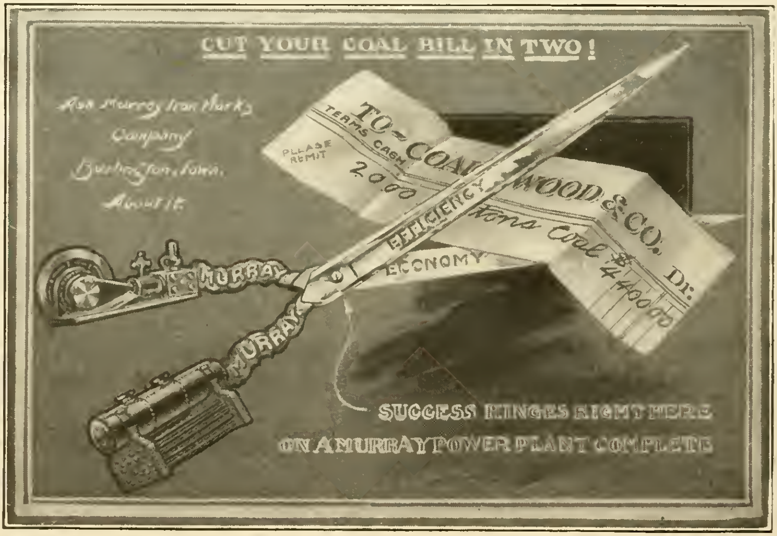

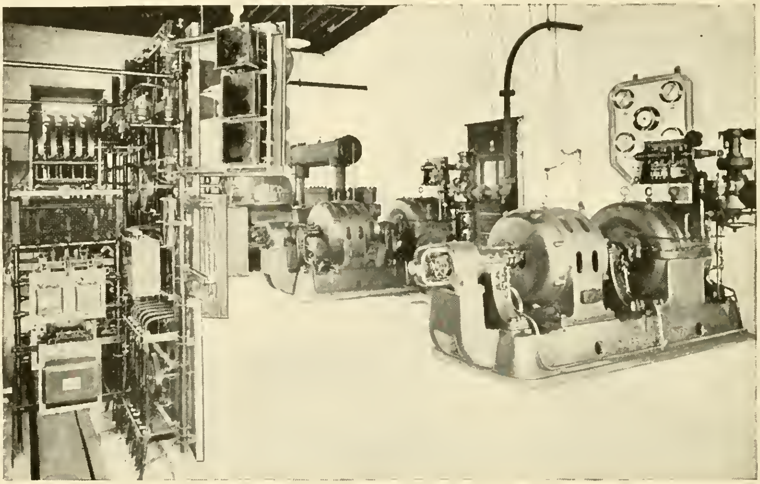

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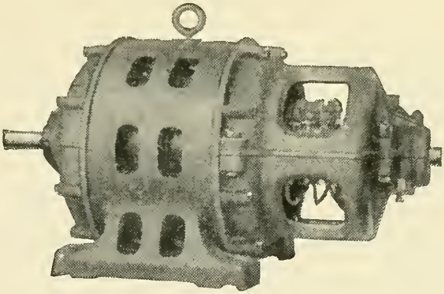

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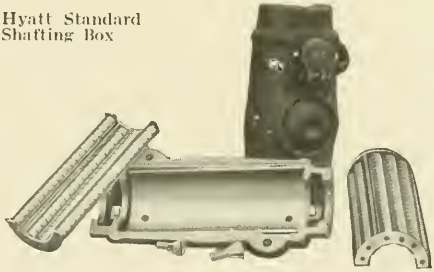

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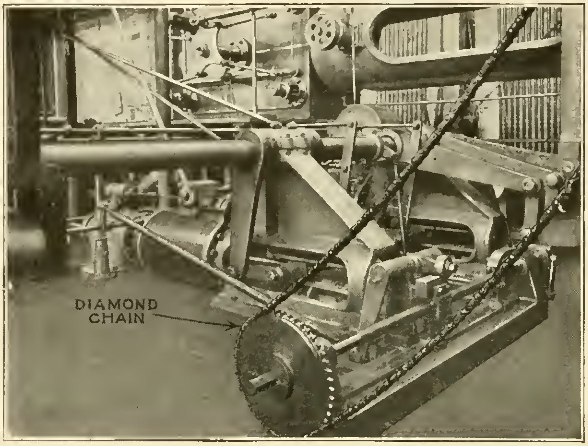

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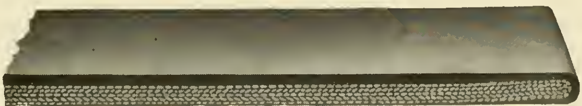

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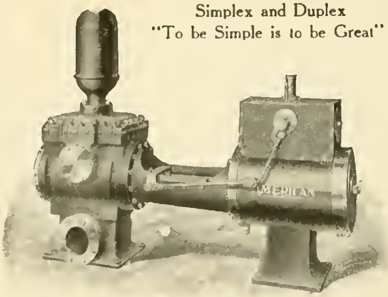

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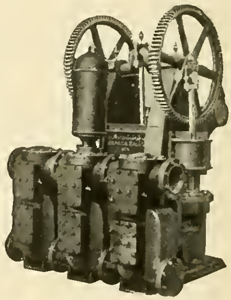

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Nov. 20, 1894	Apr. 27, 1909
May 6, 1902	Aug. 3, 1909
Feb. 2, 1907	Aug. 17, 1909
June 18, 1907	Dec. 28, 1909
Aug. 13, 1907	June 7, 1910
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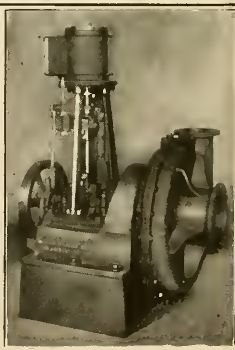

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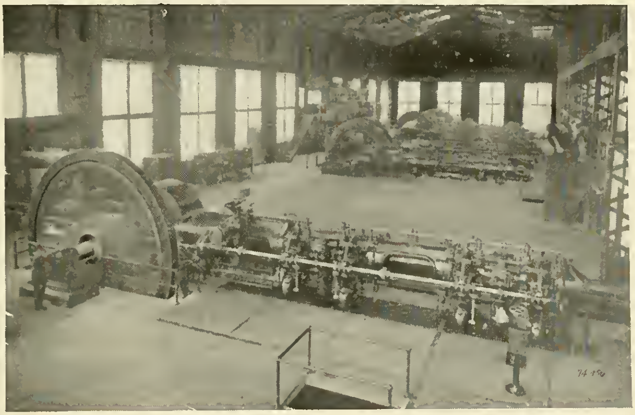

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2. In Building Additions

If it has been found necessary to build additions, it is important to lay them out in such a way as to secure the most economical routing of materials and to comply in other particulars with the requirements of scientific management. These additions must lend themselves readily to still further expansion.

3. In Laying Out New Plants

The process of manufacture should be carefully studied in order to lay out a plant in which the highest efficiency can be attained and where departmental areas have been so closely estimated that there is no idle investment on account of unoccupied plant. A comprehensive scheme of expansion should be indicated in order to obviate expensive mistakes through building additions which do not accord with the latest practice as to physical facilities and administrative methods.

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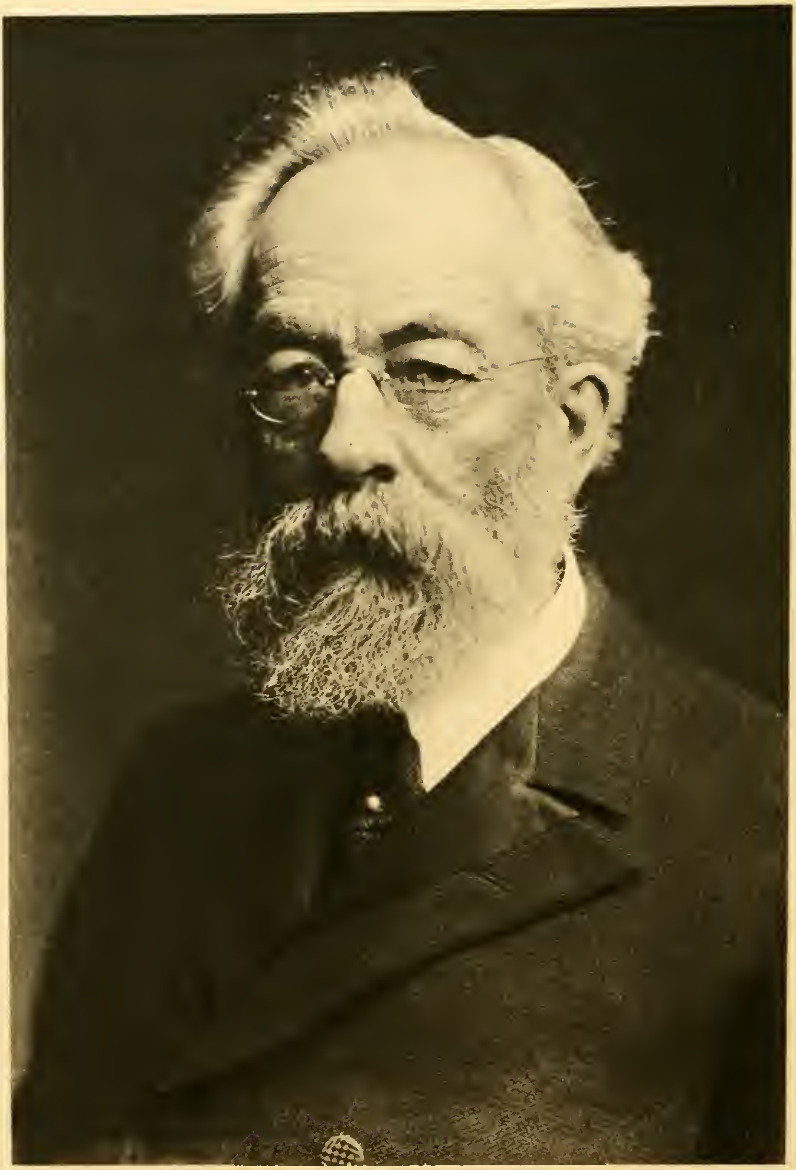

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OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MARCH 1911 VOL. 33 No. 3

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OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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CONTENTS

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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 33 MARCH 1911 NUMBER 3

THE SPRING MEETING

The 63d meeting of the Society will be held in Pittsburgh, Pa., from May 30 to June 2, 1911. Not since 1884 has a meeting of the Society been held in that city, which was for that reason given first choice by the Council, although much gratification has been felt over the numerous invitations received from different parts of the country. An effort was made to place the date earlier in the month of May in order to render it convenient for the large number of members connected with the universities and colleges, but this proved impossible because of conventions of other societies already arranged for.

An Executive Committee of members of the Society in Pittsburgh has been chosen, with E. M. Herr, Chairman, and E. K. Hiles, Secretary, and the following members, each serving as chairman of a subcommittee: George Mesta, Committee on Finance; John M. Tate, Committee on Entertainment; Chester B. Albree, Committee on Hotels; Morris Knowles, Committee on Printing; D. F. Crawford, Committee on Transportation. A Ladies' Committee will as usual care for the entertainment of the visiting ladies.

The headquarters of the meeting have not yet been chosen but members who desire to make early application for hotel accommodations should write to the chairman of the Committee on Hotels. These will be given careful attention in the order of their receipt.

MONTHLY MEETINGS

NEW YORK MEETING, MARCH 10

A meeting of the Society in New York will be held in the Engineering, Societies Building, on Friday evening, March 01, in coöperation with the American Institute of Electrical Engineers. The subject of the meeting will be The Cost of Industrial Power. Papers will be presented on power costs by members of both organizations and those having intimate knowledge of the cost of producing power in both central or isolated and industrial plants are expected to participate in the discussion.

SAN FRANCISCO MEETING, MARCH 10

At a meeting of the Society in San Francisco, March 10, Pacific Coast Practice in the Use of Crude Petroleum will be the subject of a general discussion. This topic was considered at the meeting of the Society in San Francisco on December 16, when eight contributions covering various phases, were presented. These papers and the topic in general will be considered at the coming meeting.

BOSTON MEETING, MARCH 17

A meeting of the Society will be held in Boston on March 17. The paper by Wm. F. Uhl, Speed Regulation in Hydro-Electric Plants, will be discussed. The Boston Section of the American Institute of Electrical Engineers and the Boston Society of Civil Engineers have been invited to attend.

NEW YORK MEETING, FEBRUARY 14

A meeting of the Society in New York was held on February 14 in the Engineering Societies Building, with an attendance of 81. The topic of the evening, The Mechanical Engineer and the Prevention of Accidents, was presented by John Calder of Ilion, N. Y., who gave in abstract his paper on the subject, analyzing the causes of accident and citing various methods for guarding equipment and processes, drawn chiefly from his own experience in plant management. The

paper was discussed by F. R. Hutton, representing the American Museum of Safety; Byron Cummings, representing the Ocean Accident and Guarantee Corporation: Luther D. Burlingame of the Brown and Sharpe Manufacturing Company; M. W. Alexander of the General Electric Company, Lynn, Mass., who has served as a Commissioner of the State of Massachusetts in working out compensation laws; L. B. Alford, Engineering Editor of the American Machinist; David Van Schaak of the Aetna Insurance Company of Hartford, Conn. Written discussions were contributed by Oberlin Smith, President of the Ferracute Machine Company, Bridgeton, N. J., and Alexander Taylor, of the Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa. Lantern slides were used by Mr. Calder, Professor Hutton and Mr. Burlingame to illustrate their remarks.

At the close of the meeting a large number of those present availed themselves of the invitation extended by the American Museum of Safety to inspect their exhibit on the sixth floor. The museum contains many models of safeguarding machines and operations, in particular a very complete collection of those used by the United States Steel Corporation, all of which were of interest to the visitors.

BOSTON MEETING, FEBRUARY 17

The Society, together with the Boston Society of Civil Engineers coöperated on February 17 in a meeting of the Boston Section of the American Institute of Electrical Engineers, which was held in the auditorium of the Edison Electric Illuminating Company. A paper entitled Economic Limitations to Aggregations of Power Systems was presented by R. A. Philip, Assoc. Mem.A.I.E.E., of the Stone and Webster Engineering Corporation, covering a study of the factors governing the extension and growth in transmission systems and their interconnection, assuming constant potential conditions throughout a system. It was discussed by Herman T. Wilcox of the Lowell Electric Corporation; C. A. Adams of Harvard University; Mr. Ekein of the Stone and Webster Engineering Corporation; A. E. Kennelly of Harvard University; E. N. Lake of the Stone and Webster Engineering Corporation; and F. E. Frothingham, Mem.Am.Soc. M.E., of Perry, Coffin and Burr. About 180 were in attendance. This paper was published in the February issue of the Proceedings of the American Institute of Electrical Engineers.

ENGINEERS' DINNER AT BOSTON

An engineers' dinner, attended by more than 400 representatives of the profession as a whole, similar in character to that of a year ago, was given in Boston on the evening of January 31 in the Hotel Somerset. The arrangements for the gathering were in charge of the Boston Section of the American Institute of Electrical Engineers, the Boston Society of Civil Engineers and The American Society of Mechanical Engineers coöperating. John F. Vaughan, Chairman of the Boston Section of the American Institute of Electrical Engineers, presided and called upon Prof. Ira N. Hollis, Mem.Am.Soc.M.E., to give the present status of plans for an engineering building, as formulated by the committee appointed at the dinner of 1910. Professor Hollis reported that as a result of a number of meetings it had seemed best to securea site in the center of Boston, and that the committee had already passed upon two or three locations. The cost of an adequate building, he said, would be between $30,000 and $50,000.

J. J. Carty, Mem.A.I.E.E., chief engineer of the American Telephone and Telegraph Company, who represented the American Institute of Electrical Engineers in the absence of President Jackson, spoke of the part of the engineer in the revolution in conditions of life which is taking place in America, and of the need of his entrance into public affairs to a greater extent than heretofore.

Mr. Carty was followed by Col. E. D. Meier, President Am.Soc. M.E., who spoke of the debt of America to New England. He said that, as a new nation, we were obliged to borrow from the older nations of Europe, but that after they had given us the science it was the American mechanic and the American engineer who made use of the facts of those sciences and brought them into practical shape for service to men. It was a Yankee, Benjamin Thomson, who demonstrated experimentally the mechanical equivalent of heat at Munich. It was a New Englander, Joseph Francis, who invented and built the first internal discharge turbine and realized an economy which has not yet been excelled. The engineers and machine builders of Europe had been improving the steam engine for nearly half a century without making much progress in its economy until a Yankee, George H. Corliss, showed them the way by his wonderful

discovery, making possible the real economy of the steam engine. In the early days of steam navigation, it was Yankee clippers built in our shipyards here which set records the early Atlantic steamers were unable to break. The first industry to expand, the textile, derived its possibilities from the invention of the cotton gin by Whitney; and when steam was needed to help out water power, Corliss and those who followed him stepped into the breach. The production of anything in quantities, the actual manufacture of machinery, was inaugurated in America. Muskets and rifles had been made in Europe for many years, but it was at the Springfield armory that they were first made by the thousand, by making all the parts interchangeable—an American and a Yankee idea. The mechanical genius of the nation was equal to the difficulties of building railroads, which on account of the vast distances, great ranges of mountains, immense streams, were much greater here than in Europe, and while the first railroads were crude, there were today none in the world which can compete with some of those in America. Men like Faraday, Volta, Ohm and Siemens were leaders in the science of electricity; but it took men like Thomson, Edison and Field to develop it into the practical uses of mankind. The first submarine cable was the project of Americans and was laid by them. He voiced in conclusion his hearty approval of such gatherings of the profession as a whole and said that while none of us as individuals could know more than a little, as a body we were possessed of much knowledge.

Henry F. Bryant, President of the Boston Society of Civil Engineers, the oldest engineering society in America, followed Colonel Meier and further emphasized the great need of coöperation in the different branches of engineering, adding his hope that the engineering building in Boston would soon cease to be theory and become a practical reality.

The speaker of the evening, Prof. Elihu Thomson, Mem.A.I.E.E., of Lynn, Mass., was introduced by President Richard C. MacLaurin of the Massachusetts Institute of Technology.

Professor Thomson said that while electrical engineering is the youngest of the engineering branches, we are finding that the universe is really and fundamentally electrical—that matter itself is composed of electrical corpuscles, and that the forces that act on matter, inertia, momentum, gravitation, etc., are in their very essence electrical; so that we are occupying the universe theoretically if not practically. In the progress of engineering. we have seen in the past ten, fifteen or twenty years very great changes and advances. We are living indeed in what we might call the scientific age. Formerly men had to

do their work by empirical methods and were obliged to do a great deal of guessing. They had to work by a sort of intuition, particularly in the early days of electrical engineering. Even now we have not by any means gotten over it, but need more and more information. The pure science of this day is the applied science of the day far in advance. "When Davy put the batteries together and the two little carbon points, one against the other, and then drew them apart, he formed what he called an arch of light. It was the arc of today. Davy in writing his description of it said: 'It is a truly gorgeous experiment.' That was all. But just think what the arc means in electrical engineering."

Emphasizing the need of greater support of our technical schools, he said: "I look forward to the time when the technical man, the well-informed scientific technically trained man, will be a factor of far greater consequence in the community than he is today. I look forward to the time when no business man will enter upon an enterprise without first having the opinion of one or more well-informed technical men. How much money is thrown away in all sorts of worthless ventures, when, if the business man always had it in mind to say, 'There must be somebody who knows about this a great deal better than I do and I will consult him,' how much wastage would be saved. How many enterprises which are merely on paper would be downed from the start. How many ways of gambling, so to speak, would be stopped in their inception.

If we look into the future far enough we will see that what has come about in reference to pure food will come about concerning these other things. It will be made a misdemeanor and something that cannot legally be done, to foist upon the public schemes which have not the proper endorsement of technical men; and the technical man will then come into his own.

I think a gathering of this kind, a union of engineers, is of great value in bringing out the views of engineers themselves; for let a body of engineers, one dealing with one sort of problems and another with another sort, talk together, and the result is undoubtedly very highly educational. A man goes away from a meeting of that sort with a broader and more comprehensive view of the work that is being done in the world; and a broad man is, of course, a valuable man because he is always able to tell in what direction information should be looked for and who are the best men to furnish it."

Prof. Arthur E. Kennelly, Mem.A.I.E.E., acted as toastmaster and added much to the occasion by his apt introductions. The evening concluded with a rising vote of thanks to the speakers.

LETTER FROM ADMIRAL MELVILLE

The following letter has been received from Rear-Admiral George W. Melville, Honorary Member of the Society, in reply to a elegram of congratulation from the Council on his seventieth birthday.

Philadelphia, January 17, 1911

Col. E. D. Meier, President,
The American Society of Mechanical Engineers,
29 West 39th Street, New York City, N. Y.

My dear Colonel:

I have been so busy since my seventieth birthday on the 10th inst., that I am just taking up the pleasant duty of acknowledging the kind words of congratulation which have been received from my friends in such large number.

One of the congratulatory messages which I prize most highly is your telegram of the 10th inst., transmitting the good wishes of the Council of the Society, which was in session that day.

May I ask you to convey to the members of the Council my sincere thanks for their remembrance, which is only another of the courtesies and acts of appreciation which the Society has shown me during many years.

Believe me, with kindest regards,

Your sincere friend,

(*Signed*) Geo. W. Melville

STUDENT BRANCHES

ARMOUR INSTITUTE

The Armour Student Branch held a regular meeting, January 4, 1911, at which Chas. E. Sargent, Mem. Am. Soc M. E., read a paper on Gas Engines, illustrating by lantern slides various types of engines and working parts. At the meeting on February 1, Prof. A. J. Anderson gave an address on Railway Draft Gears which was also illustrated by slides.

BROOKLYN POLYTECHNIC INSTITUTE

On January 7 at a meeting of the Polytechnic Institute Student Branch F. R. Low, Mem. Am. Soc. M. E., Editor of Power, gave an interesting illustrated lecture on Entropy, following the business of the evening. On February 4, Prof. W. D. Ennis, Mem. Am. Soc. M. E., gave an instructive talk on Flying Machines.

CORNELL UNIVERSITY

At the first meeting of the Sibley College Student Branch on October 21, Professor Ford gave an impromptu talk on The Field of the Technical Graduate. On November 18, D. S. Wegg, Jr., Jun. Am. Soc. M. E., was elected corresponding secretary in place of C. F. Hirshfeld, resigned. C. C. Trump (1911) presented a paper on the Humphrey Gas Pump which was illustrated by lantern slides. The organization expected to have with them on December 15 Prof. John E. Sweet, Hon. Mem. Am. Soc. M. E., but he was unable to be present and Prof. D. S. Kimball, Mem. Am. Soc. M. E., kindly volunteered to take his place. Professor Kimball spoke upon the Modernization of the Power Plant at the United States Hospital for the Insane at Washington, D. C.

LELAND STANFORD JUNIOR UNIVERSITY

At the meeting of the Leland Stanford Junior University Student Branch on February 2, F. O. Ellenwood addressed the members on

Gas Engine Ignition. This subject was further discussed by Prof. Wm. F. Durand, Mem.Am.Soc.M.E., and Prof. S. B. Charters, Jr., both of the university.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At the meeting of the Mechanical Engineering Society of the Massachusetts Institute of Technology, on February 10, Ralph E. Flanders, Mem.Am.Soc.M.E., addressed the members on the subject of Gear Cutting Machines, dividing it into its important branches and discussing each branch in detail. The lecture was illustrated by lantern slides.

The annual dinner and meeting of the society are being planned for the second week in March and will probably be held at the Boston City Club. Among the guests and speakers will be Prof. Gaetano Lanza, Mem.Am.Soc.M.E., Prof. Edw. F. Miller, Mem.Am.Soc. M.E., Prof. Ira N. Hollis, Mem.Am.Soc.M.E., and I. E. Moultrop, Mem.Am.Soc.M.E.

PENNSYLVANIA STATE COLLEGE

On February 7, at the meeting of the Pennsylvania State College Student Branch, a paper was presented by H. E. Davis (1910), on Methods of Welding Aluminum, dealing especially with soldering, welding with hydrogen, and with oxy-acetylene.

PURDUE UNIVERSITY

At a meeting of the Purdue Student Branch, February 9, the following officers were elected: L. Jones, Chairman; C. Abbott, Vice-Chairman; H. E. Sproull, Corresponding Secretary; A. Harter, Secretary; and C. E. Trotter, Treasurer. After this business had been transacted, W. A. Hanley (1911) gave an interesting talk on The Relation of Flue Gases to the Efficiency of Boilers, based on experience gained during the summer of 1910, while in the employ of the American Gas and Electric Company.

UNIVERSITY OF CINCINNATI

At a meeting of the University of Cincinnati Student Branch held on January 27 a lecture was given by Geo. K. Elliott, of the

Lunkenheimer Company, on Industrial Alloys, illustrated with microphotographic slides. A luncheon followed the address.

UNIVERSITY OF KANSAS

The second annual meeting of the Kansas University Student Branch was held in Lawrence on January 5 in the assembly hall of the main engineering building and brought out many interested visitors and students. The program included papers on Some Recent Improvements on Locomotive Boiler Construction, by Wm. J. Leighty of Topeka, Kansas; Results of a 7 hr. Test on an Air-Lift Pumping Outfit, by John D. Farrell (1911) and Thomas A. Purton (1911); Results of a 2-hr. Test of an 1100-h.p. Gas Engine, by Wilbur H. Judy, Chairman of the Student Branch. Two addresses were made, one on Scientific Management,by Prof. H. Wade Hibbard, Mem. Am. Soc. M. E., of the University of Missouri; and the other on Aeronautics, by Capt. Charles DeForest Chandler, U. S. A. The latter was illustrated by a number of instructive lantern slides. A banquet was given in the evening in honor of the guests, Prof. P. F. Walker, Mem. Am. Soc. M. E., acting as toastmaster.

On February 9, a paper on Modern Installation for Power and Refrigeration in a Packing Plant was presented by M. C. Conley. The topical discussion on Smoke Abatement was also considered at this time.

UNIVERSITY OF MAINE

At a meeting of the University of Maine Student Branch, held on January 5, a paper upon the Unidirectional Flow Steam Engine was presented by W. W. Hatch (1911). The characteristic features of the engine were described and the factors affecting the engine's efficiency were well pointed out, lantern slides being used by way of illustration.

UNIVERSITY OF MISSOURI

The following officers of the University of Missouri Student Branch were elected at the meeting of January 19: F. T. Kennedy (1910), president; G. D. Mitchell (1910), secretary and treasurer; Osmer N. Edgar (1910), corresponding secretary.

UNIVERSITY OF NEBRASKA

At a joint meeting of the Student Branch of the Society in the University of Nebraska with the Student Section of the American Institute of Electrical Engineers on January 19 plans were formulated for a trip to Omaha in the Spring, to inspect the shops and power-houses of the city. Two papers were presented: A Plea for the Draftsman, by Prof. Philip K. Slaymaker, and Ventilating Engineering, by Prof. L. A. Scipio. A second joint meeting of the two organizations was held on February 9, at which Prof. C. R. Richards, Mem.Am.Soc.M.E., read a paper on Refrigerating Engineering.

UNIVERSITY OF WISCONSIN

The University of Wisconsin Student Branch held a joint meeting with the Madison Branch of the American Institute of Electrical Engineers on January 17. A. L. Goddard, Mem. Am. Soc. M. E., presented a paper upon Machine Tool Motor Drives, speaking of various applications of constant speed motors to lathes, planers, boring and drilling machines where variable speed was obtained by means of step pulleys and the weight of the motor assisted in keeping the proper tension in the belts. This was discussed by A. G. Christie, Assoc. Am. Soc. M. E., and H. B. Sanford. They were followed by A. Hirsch who gave a talk upon Alcohol Distillation, in which he treated of differential condensation in distillation and rectification of alcohol and water mixtures, and showed how this method was realized through research in the laboratory and applied commercially so as to reduce the difficulty of getting a high alcohol percentage.

YALE UNIVERSITY

Charles Whiting Baker, Mem. Am. Soc. M. E., Editor of Engineering News, delivered an illustrated lecture on The Panama Canal at the meeting of the Yale Mechanical Engineers Club on January 24. This was followed by an informal discussion.

REPORTS

MEETING OF THE COUNCIL

A meeting of the Council was held on February 14, in the rooms of the Society. There were present: E. D. Meier, President, presiding, C. W. Baker, James Hartness, Charles Wallace Hunt, F. R. Hutton, E. B. Katte, I. E. Moultrop, Jesse M. Smith, F. W. Taylor, H. G. Reist, Alex. C. Humphreys, and the Secretary. Regrets were received from D. F. Crawford, George M. Brill, H. L. Gantt, H. H. Vaughan, W. F. M. Goss, and Stanley G. Flagg, Jr.

The President reported that as a result of extended discussion at a previous meeting of the Council, the Executive Committee had held a meeting to consider a change in present policies, to provide for the conditions of the Society's development. As a result of this meeting a special committee has been appointed, consisting of three members of the Executive Committee, the Chairman of the Committee on Meetings and of the Publication Committee, and the President and Secretary. The Secretary read the report, including suggested changes in the Rules.

Voted: To receive the report, but to defer action until the next meeting of the Council.

Voted: That the Secretary be directed to send a copy of the edited report together with the draft of the proposed amendments to the Rules, to the members of the Council, the Publication Committee, Committee on Meetings, Committee on Constitution and By-Laws, and to the secretaries of the local committees and Gas Power Section for their opinion and comment, the report then to be referred back to the Special Committee for consideration and report as a special order of business for the Council Meeting of March 10.

Voted: To refer to the Committee on Constitution and By-Laws the letter of the Third Assistant Postmaster-General, together with the recommendations of the Publication Committee, and that the former committee proceed to prepare draft and report to the Council proposed changes in the Constitution and By-Laws of the Society to comply with the law.

Voted: That the Publication Committee be requested to investigate the subject of reducing the weight of The Journal and report to the Council.

Voted: That the previous decision of the Council adverse to the use of emblems by Student Branches be rescinded.

Voted: That the requests for such emblems be referred to the Committee on Student Branches to consider and report suggestions for approval by the Council.

The Secretary reported the following deaths: J. B. Edson, J. O. Norbom, J. W. Seaver, L. R. Alberger, Chas. H. Morgan.

Voted: To confirm appointment by the President of the following Honorary Vice-Presidents to attend the funeral of Mr. Morgan: Geo. I. Alden, F. H. Daniels, Charles M. Allen, M. P. Higgins, Geo. I. Rockwood, C. J. H. Woodbury.

Voted: To accept the resignations of J. H. Kendall, and W. H. Horton.

Voted: To approve the action of the Executive Committee in selecting Pittsburg for the Spring Meeting of the Society, May 30–June 2.

The suggestion was approved that in the future the decision regarding time and place for the Spring Meetings be made annually at the preceding Spring Meeting.

The Secretary read the minutes of January 30, 1911, of the Committee on Public Relations containing the recommendations of that Committee to the Council.

Voted: That the Committee on Public Relations be requested to confer with the representatives of other societies having the matter of Licensing Engineers in hand, with the hope of doing the utmost to secure concerted action.

Voted: That to conform to other standing committees the terms of office of the members of the Committee on Public Relations be as follows: Robert W. Hunt, one year; D. C. Jackson, two years; J. W. Lieb, Jr., three years; Fred J. Miller, four years.

The President announced the reappointment of James M. Dodge on the Committee on Public Relations to serve for a term of five years.

Voted: To approve the recommendation of the House Committee that the introduction card be issued annually and serve as a receipt for dues, the details to be left to the Committee for execution.

Voted: To approve the appointment of sub-committees of the Research Committee and that the Chairman be empowered to make such appointment from men prominent in the profession irrespective of their membership in the Society.

Voted: That F. R. Hutton be appointed a member of the Committee on Power House Piping, to fill the vacancy caused by the death of Wm. H. Bryan.

Voted: To accept the report of the Special Committee, Chas. Wallace Hunt, Chairman, Robert M. Dixon, and W. H. Marshall, on plan for the liquidation of the land debt outstanding as the share of this Society, leaving details of its execution to the committee.

Voted: That the report of the Treasurer of the United Engineering Society be placed on file and that the condensed report as prepared by the President and Treasurer of the Board of Trustees for the purpose of uniform publication by the Founder Societies be published in The Journal.

Voted: That F. R. Hutton and Calvin W. Rice be appointed Honorary Vice-Presidents to represent the Society at the conference proposed by the National Electric Light Association to consider the subject of resuscitation from electric shock.

Voted: To approve the action of the Secretary in responding to the invitation of the Louisiana Engineering Society to hold a meeting of this Society in New Orleans, and to further advise that the Council hopes at some future date to take New Orleans under consideration for some semi-annual meeting.

Voted: To place on file the letter of Rear-Admiral Melville in answer to the congratulatory telegram sent by the Council on his seventieth birthday, and that same be published in the next issue of The Journal.

On motion the meeting adjourned.

UNITED ENGINEERING SOCIETY

REPORT OF TREASURER

To the Board of Trustees
United Engineering Society

I beg to submit herewith report of your treasurer as of December 31, 1910.

FINANCES

From the Balance Sheet submitted herewith, it appears that our physical property, over and above the value of the building and our equity in the land, consists of building equipment amounting in value to $16,767.72, furniture and fixtures $4376.92 and library books $205.16.

During the year 1910 there was added to the furniture and fixtures account an amount representing an expenditure of $1455.72 including furniture in the Board Room and Ladies' Reception Room, directory and bulletin boards, partition and counter in Room 607, and miscellaneous items; and books for the library amounting to $205.16, the cost of the library books being charged equally to the three Founder Societies in accordance with agreement.

The principal of the mortgage on the land held by Andrew Carnegie, Esq., amounting originally to $540,000, has been reduced by payments from the Land and Building Funds of the Founder Societies to $220,000, the American Institute of Mining Engineers having made a further payment of $3000 during the year, correspondingly reducing the burden on the Founder Societies for payment of interest.

The gross operating expenses for the year 1910 were $35,961.97. Deducting the expenditures for furniture and fixtures to the amount of $1455.72, the net cost is $34,506.25, which is slightly in excess of that of 1909, due to the fact that the building is now practically full to its capacity, necessitating the use of more electric light, power, heat, etc., and a small increase in the service payrolls.

In accordance with a resolution to the Board at the meeting held on January 27, 1910, an appropriation of approximately $5000 was made out of the surplus remaining from the year 1909, and this amount ($5062.50) was invested in New York City 4¼ per cent Bonds as an addition to the Contingency and Renewal Fund as provided for in the Founders' Agreement, bringing the Reserve Fund up to $15,331.25. It is recommended that a similar appropriation be made out of the available balance from this year's operations leaving a surplus to be carried forward of $5060.88.

The assessments paid for the year 1910 by the Founder Societies each occupying one entire floor were $4500 each, representing a total expenditure by each, including interest on its full principal of mortgage on land of $11,700 reduced in each case to the extent the society may have paid of part of its mortgage share. As the associate societies are assessed approximately $10,000 for equivalent facilities, it will be seen that the Founder Societies are still carrying more than their proportion of the carrying charges for equivalent office-space occupancy in the building.

OCCUPANCY OF BUILDING

Attention is called to the fact that on January 1, 1911, the unoccu-

pied floor space in the building was equivalent in rental value to 18 per cent of the total space available for assessment, and not including room No. 705 which is used by the Trustees as a Board Room. Even this room is occasionally used by other societies or organizations.

Attention is particularly directed to the small number of times the auditorium has been occupied during the past year, 36 times in 1910 as compared with 30 times in 1909, and the relatively small demand for the two assembly rooms on the fifth floor, No. 1 having been occupied 25 times and No. 2, 53 times in 1910; as compared with 26 and 48 times respectively in 1909. The limited use made of the auditorium and of the two assembly rooms, the income therefrom barely covering their quota of the fixed charges, continues to be a problem in the economical administration of the building.

During the year 1910 there have been the following changes in the assignment of space in the building:

a Owing to the greater demand for office occupancy than for lecture rooms, the large room on the sixth floor, known as Lecture Room No. 6, has been withdrawn from the list of lecture rooms and is now occupied as an office and museum.

b The room on the twelfth floor, originally held in reserve for possible future extension of the Library or for a museum, has been utilized since the building was first occupied as a general storeroom for the three Founder Societies. In the late summer, the books and stock stored in this room were moved to other but less convenient places in the building and the room divided by partition into two sections, giving with the small adjacent lecture room on the twelfth floor, a suite of three rooms which is now used in the evenings by Columbia University Extension Courses in Architecture.

During the past year the facilities of the building were enjoyed by 60 societies, founders and associates, with a total of 251 meetings and an attendance of 30,722, as compared with 52 societies with a total of 211 meetings and an attendance of 25,338 in 1909.

LIBRARY

The attendance at the library is given in the subjoined table:

	1910	1909	1908
Day	6535	5901	5151
Night	2795	2402	2080
Total	9330	8303	7231

showing an increase in 1910 as compared with 1909 of 634 in day attendance and 393 in night attendance, a total of 1027. The library is becoming more widely known, and the books and periodicals are more and more frequently consulted by a constantly increasing number of both members and non-members.

Respectfully submitted,

(*Signed*) Jos. Struthers,

Treasurer

UNITED ENGINEERING SOCIETY

Balance Sheet, January 1, 1911

ASSETS

Real Estate, Land		$ 540,000.00
Real Estate, Building		1,050,000.00
Real Estate, Equipment		16,767.72
Furniture and Fixtures		4,376.92
New York City bonds (cost) reserve		5,231.25
New York City bonds (cost) reserve		5,062.50
Balto. & Ohio bonds (cost) reserve		5,037.50
Library books, United Engineering Soc. (in trust)		205.16
Library, adjustment accounts		164.20
Accounts receivable		3,466.00
Cash		
Working balance	$10,004.22	
For reserve fund	5,000.00	
Ways and Means Com	1,165.08	16,169.30
Petty cash		500.00
		$1,646,980.55

LIABILITIES

Balance of land mortgage, A.I.E.E.	$54,000.00	
Balance of land mortgage, A.S.M.E.	81,000.00	
Balance of land mortgage, A.I.M.E.	85,000.00	$220,000.00
A.I.E.E. equity in Building		350,000.00
A.S.M.E. equity in Building		350,000.00
A.I.M.E. equity in Building		350,000.00
A.I.E.E. equity in real estate equipment		3,346.61
A.S.M.E. equity in real estate equipment		3,346.62
A.I.M.E. equity in real estate equipment		3,346.62
A.I.E.E. payments to date in liquidation of mortgage on land.		126,000.00
A.S.M.E. payments to date in liquidation of mortgage on land.		99,000.00
A.I.M.E. payments to date in liquidation of mortgage on land.		95,000.00
Depreciation and reserve fund		20,000.00
Ways and Means Committee		1,165.08
Library, adjustment accounts		133.45
Accounts payable		1,341.26
Balance, cash, accounts receivable, furniture, etc		24,300.91
		$1,646,980.55

Statement of Receipts and Disbursements, Year Ending December 31, 1910

CASH RECEIPTS

Balance on hand January 1, 1910	$10,099.88
Account of reduction of mortgage on land	3,000.00
Account of interest on mortgage	8,920.00
Assessment of Founder Societies	13,500.00
Assessment of Associate Societies, offices, meetings, etc	35,661.79
Library account	5,357.85
Interest on bonds and deposits	679.65
	$77,219.17

DISBURSEMENTS

Account reduction of mortgage on land	$3,000.00
Account of interest on mortgage	8,920.00
Operating expense, Cash expenditures	33,170.99
Furniture and Fixtures	1,449.72
Library account	5,271.60
Bonds purchased (reserve)	5,062.50
Accrued interest on bonds purchased	21.84
Accounts payable (from 1909)	1,150.00
A.I.M.E. office space released	2,809.33
Insurance	362.97
Library adjustment	819.89
Library books, U.E.S.	176.11
Balance on hand, January 1, 1911	15,004.22
	$77,219.17

Operating Income and Expenses, Year Ending December 31, 1910

INCOME

Assessment Founder Societies	$13,500.00	
Less refund for office space released	2,809.33	$ 10,690.67
Assessment Associate Societies		23,824.30
Assessment miscellaneous (offices and meetings)		6,814.50
Telephone returns		3,284.00
Miscellaneous charges to societies		851.17
U.E.S. library book returns		205.16
U.E.S. library returns		58.21
Interest		657.81
		$46,385.82

EXPENSES

Operating expenses, gross	$34,506.25
Furniture and Fixtures, gross	1,455.72
Reserve fund	5,000.00
Insurance	362.97
Balance to surplus	5,060.88
	$46,385.82

NECROLOGY

CHARLES HILL MORGAN

Charles Hill Morgan was born January 8, 1831, in Rochester, N.Y. His parents, Hiram and Clarissa L. (Rich) Morgan, were of old New England stock, the line of his father going back to Miles Morgan, one of the founders of Springfield, Mass., who came to this country in 1636, from Bristol, England.

Mr. Morgan's father having been a mechanic of limited means, the son Charles was obliged to work in a factory at the age of twelve, and his early education was that afforded by the Massachusetts district school of seventy years ago, and short terms in the Lancaster Academy. When fifteen he entered the machine shop of his uncle, J. B. Parker of Clinton, Mass., as an apprentice.

At seventeen he determined to learn mechanical drawing and through his efforts a class for the study of this subject was formed, taught by John C. Hoadley, late member of The American Society Mechanical Engineers, then civil engineer of the Clinton Mills. Those few lessons in drawing, taken at night, after twelve hours of work in the shop, were the most important factor in establishing Mr. Morgan's mechanical career, and perhaps of several others in that class.

In 1852, when twenty-one, Mr. Morgan was put in charge of the Clinton Mills dye-house. He devoted himself to the study of chemistry with great zeal, and filled his new position with entire success, gaining valuable experience in the management of subordinates.

For a time Mr. Morgan was draftsman for the Lawrence Machine Company. Later, from 1855 to 1860, he was mechanical draftsman for the distinguished inventor and manufacturer, Erastus B. Bigelow. In association with him and Charles H. Waters, the agent of the Clinton Wire-Cloth Mills, Mr. Morgan gained an invaluable experience and may be said to have been trained in a hive of invention. Mr. Morgan introduced a system of designing and constructing cam curves for looms. This system proved of great value and was later the subject of a valuable paper read before the Worcester Polytechnic Institute, and subsequently published by Mr. Morgan in pamphlet form.

Forming a partnership in 1860 with his brother Francis H. Morgan, he was for several years engaged in the manufacture of paper bags in Philadelphia, and during a part of this time a paper mill was operated by the firm near Coatesville, Pa. Previous to this time the imperfections in machinery had made paper bag making in the United States anything but a success. Mr. Morgan perfected the equipment so that the business was placed on a commercial footing.

In 1864 Hon. Ichabod Washburn was in need of a superintendent for his works, for the manufacture of wire, at Worcester, Mass. His friends at Clinton, engaged in the manufacture of machinery and wire-cloth, warmly recommended Mr. Morgan. Mr. Washburn accordingly engaged Mr. Morgan as superintendent of manufacturing for the firm of I. Washburn and Moen of Worcester, Mass. Four years later, when a joint-stock company was organized and incorporated under the name of Washburn and Moen Manufacturing Company, Mr. Morgan became general superintendent. He made many trips to Europe for the purpose of visiting the mills of England, Belgium, Germany, France and Sweden. Through these visits, through the publications devoted to wire manufacturing, and through patents issued both in Europe and America, he kept himself informed of all changes made or improvements adopted. The fruit of this devotion was seen in the increased excellence, variety and amount of the company's manufactures. He was for eleven years one of the directors of the company.

Mr. Morgan has been most prominently identified with the development of the continuous rolling mill, and today in steel centers the world over the continuous mill is known as the Morgan mill.

The first continuous mill was designed and originally constructed by Mr. George Bedson, in Manchester, England. One of these mills was purchased by Washburn and Moen Manufacturing Company, and erected in Worcester in 1869, and constituted a great advance over the rolling previously practiced. It soon became evident that the means of handling the product of the mill were inadequate and the first important step in development was the power reel designed by Mr. Morgan to replace the old-time hand-operated reel.

Mr. Morgan's second, and very important contribution to this system, that, indeed, which marked the great difference between the Bedson mill and the Morgan mill, was the practical development of a continuous train of horizontal rolls, the Bedson mill having had alternate sets of horizontal vertical rolls. This was accomplished by pro-

viding intermediate "twist guides," which gave to the metal being rolled the necessary quarter turn between the successive sets of rolls, and proved to be so successful that the Morgan mill is the only type of continuous mill now in use. Nine years after the contruction of the Bedson mill, another mill, from new designs furnished by Mr. Morgan, was built on the Belgian and continuous plans. This mill, the result of Mr. Morgan's studies, was known as the combination mill.

The third improvement was the invention, by Mr. Morgan, of automatic reels, both of the pouring and laying types, such as are now in common use in every rod mill in the world. These reels were completed and a successful test made March 10, 1886.

In 1887, after twenty-three very active years as General Superintendent of Washburn and Moen Manufacturing Company, declining health led Mr. Morgan to resign his position, and take up what then seemed likely to prove less arduous cares.

Some years, before in 1881, he had founded the Morgan Spring Company, for the manufacture of springs, and was thus the pioneer in this line of business which, at the present, is engaged in by many firms.

Manufacturers of steel products, at this time sought his advice in engineering problems, and his reputation as an engineer was in this way widely extended. This work led directly to the formation, in 1891, of Morgan Construction Company, of Worcester, manufacturers of rolling mill and wire drawing machinery.

Mr. Morgan was active in religious, corporate, charitable and educational lines throughout his life. He was closely identified with the growth and success of the Worcester Polytechnic Institute, having been a member of its Board of Trustees since the Institution was founded about forty-five years ago. In this capacity he has rendered a service of signal importance, greater even probably in its far reaching effect than his achievements in the profession of engineering. When in March 1866, the Hon. Ichabod Washburn made his gift to establish the machine-shop and working mechanical department of the Worcester Polytechnic Institute, Mr. Morgan was elected by the trustees as one of their associates, with the expectation that he would give the shop the benefit of his great mechanical genius and large experience. The expectation was not disappointed. Mr. Morgan's sagacity, his constant oversight, his inventive genius and his great business capacity were constantly at the service of the school, and the machine shop has been entirely successful, recognized everywhere as a most important and valuable part of the Institute.

In 1893, Mr. Morgan served on the Board of Judges of the World's Exposition in Chicago.

In 1900 the Navy Department being embarrassed by conflicting commercial and political claims in its award for special gun lathes, Secretary Folger nominated Mr. Morgan one of the committee of three distinguished engineers to pass upon the merits of so vital a question.

Although many years a member of The American Society of Mechanical Engineers, he was very much surprised, when in Europe in 1899, to receive a cablegram announcing his nomination to the wholly unsought office of President. In the following December he was unanimously elected to that office and served for one year. This year, 1900, was a notable one in the life of the Society, for a joint meeting was held in England with The Institution of Mechanical Engineers. On this trip three Sovereigns, Victoria of England, Oscar of Sweden and Leopold II of Belgium, summoned Mr. Morgan to an audience. In France the unusual distinction of election to honorary membership in La Société des Ingenieurs Civils de France was conferred upon him.

Mr. Morgan was always an admirer of Henry Cort, the inventor of the art of puddling iron with coal and of rolling metals in grooved rolls, and in his Presidential address before the Society, Some Landmarks in the History of the Rolling Mill, he paid a tribute to the Englishman's genius. In 1905 he had two bronze tablets erected in memory of Cort, one of which he presented to the church at Lancaster, Cort's birthplace, and the other to the church at Hampstead, where he was buried. The tablets which are exactly alike contain a finely executed bust of Cort with an appropriate inscription.

At the time of his death Mr. Morgan was President of the Morgan Spring Company and the Morgan Construction Company. He was a member of the American Institute of Mining Engineers, the British Iron and Steel Institute, the Institution of Mechanical Engineers of Great Britain, the Engineers' Club of New York, and an honorary member of the Society of Civil Engineers of France. He was also one of the founders of Plymouth Church and its first Sunday School Superintendent and for many years served on its board of deacons.

Chas. M. Allen, George I. Alden, F. H. Daniels, J. P. Higgins, Geo. I. Rockwood and C. J. H. Woodbury were appointed Honorary Vice-Presidents to represent the Society at the funeral of Mr. Morgan.

JOHN WRIGHT SEAVER

John Wright Seaver was born in Madison, Wis., January 8, 1855, and died in Cleveland, O., January 14, 1911. He was educated in the public schools of Buffalo, N. Y., and at thirteen years of age entered the machine shop of the Shepard Iron Works of that city. His technical education was obtained at a night school to which he was obliged to walk three miles from his home, after working hard all day.

In 1873 he entered the machine shop of the Howard Iron Works, and at the age of twenty he was employed by the Buffalo Car Company as assistant superintendent in charge of about one thousand men. Leaving there, he formed the firm of Seaver and Kellogg Company, where he designed and built the first steel cars in this country. These were not commercially successful as they were too far in advance of their time. After spending a year and a half in this business, he became assistant engineer of the Kellogg Bridge Works, where he made structural iron his specialty. He began at this time to attract outside attention as an engineer. In 1880 Mr. Seaver moved to Pittsburg to become chief engineer for the Iron City Bridge Works, and while in their employ designed and built a number of notable bridges and other steel structures. In 1884 he became chief engineer for the Riter-Conley Manufacturing Company and in this capacity his reputation became world wide. He designed and built furnaces, steel works, oil refineries, gasometers, buildings, bridges and other steel constructions. He was instrumental in making this concern one of the greatest of its kind in the world. In 1886 he united with S. T. and C. H. Wellman, to form the Wellman-Seaver Engineering Company, later known as the Wellman-Seaver-Morgan Company. While with this company he was vice-president and chairman of the board, and was a director at the time of his death. In 1906 Mr. Seaver associated himself with J. E. Moore, consulting and contracting engineers, and opened offices in Cleveland, O. He continued in this work until his death.

Mr. Seaver's engineering experience was most varied, including the civil, mechanical, marine and mining branches of the profession. While in Buffalo he designed and built many large marine engines, among the most prominent of which was that for the steamer Great Western a remarkable vessel at that time. He designed and built the first gantry crane used in this country and also the first steel cars. He was authority on structural steel construction of all kinds,

as well as material handling, steel and iron manufacturing and coke oven machinery, and compiled the first standard steel railroad bridge specification, which was adopted by some of the large railroad companies.

Mr. Seaver was a member of the American Society of Civil Engineers, the Cleveland Engineering Society, and of many business and social organizations.

LOUIS R. ALBERGER

Louis R. Alberger was born April 10, 1864, at Buffalo, N. Y., and was educated at the public schools of that city. He studied engineering chemistry at the Scheffield Scientific School, Yale University, and later joined his father in the firm of Alberger and Salt, builders of salt-making apparatus in which the vacuum system was incorporated. This brought Louis R. Alberger into close contact with the subject which he made his life study, and after superintending for thirteen years the condensing department of Henry R. Worthington, he incorporated the Alberger Condenser Company, in 1901, and later the Alberger Pump Company, and acquired the controlling interest in the Newburgh Ice Machine and Engine Company, Newburgh, N. Y. At the time of his death he was president of the Alberger Condenser Company.

Mr. Alberger was a member of the American Institute of Mining Engineers, the National Electric Light Association, the American Association for the Advancement of Science, Verein deutscher Ingenieure, and of a number of social and athletic organizations. He died in New York, January 31, 1911.

STUART E. FREEMAN

Stuart E. Freeman was born January 13, 1866, at Baltimore, Md. He received his early education at the public schools and later attended the Franklin Institute in Philadelphia. From 1883 to 1887 he served an apprenticeship in the Illinois Central Railroad shops, Centralia, Ill., at the end of which period, he was employed by the Dickson Manufacturing Company, Scranton, Pa. He later accepted the position of foreman with the A. Falkenau Machine Company, Philadelphia. From October 1892 until May 1893 he was general foreman for the Philadelphia Hardware and Malleable Iron Works and until January 1895 for the Morgan Engineering Company, Al-

liance, O. Mr. Freeman was subsequently employed by the Todd-Stanley Mill Manufacturing Company, St. Louis, Mo., the International Drill Company, Barberton, O., the Stirling Tubular Boiler Company, the Fuller Manufacturing Company, New Haven, Conn., and at the time of his death he was general superintendent of the Smith-Furbush Machine Company, Philadelphia.

Mr. Freeman was a member of the Franklin Institute and of the Engineers' Club of St. Louis. He died in Norristown, Pa., February 2, 1911.

JARVIS B. EDSON

Jarvis B. Edson died at his home in New York City, January 26, 1911. He was born in Janesville, Wis., April 30, 1845, and obtained his technical education at Cooper Union and at New York University, New York City. He saw active service during the Civil War, and being discharged from the army, July 1863, he connected himself with the South Brooklyn Steam Engine and Boiler Works, where he participated in the construction of several engines for United States war vessels notably the Mendota, Metacomet, Nyack and Nipsic. He later conducted a series of steam engine expansion experiments under the direct supervision of B. F. Isherwood, U. S. N., Hon.Mem. Am. Soc. M. E., chief of the Bureau of Steam Engineering.

On November 1, 1864, he was appointed Acting Third Assistant Engineer in the United States Navy and at the close of the war received his honorable discharge. Returning to private life, he invented and perfected the Edson time and pressure recording steam engine. He also engaged in the manufacture of various instruments required by engineers and for the precision of which he was obliged to construct a mercurial column some 250 ft. high for high pressure alongside the Brooklyn towers of the East River Bridge. This instrument received due corrections for temperature and density, and differed from the guesswork method previously practiced for obtaining standards from which to lay off the dials of hydraulic and other high pressure instruments. In 1873 Mr. Edson took part in the organization of the Domestic Telegraph Company and three years later devoted his attention to the manufacture and improvement of celluloid and zylonite. During this peroid he obtained many valuable patents on inventions, one of which was for a method of making artificial ivory in proxilene compounds. He also devised a novel method of sinking deep wells into clay, quicksand, gravel, etc.

Mr. Edson's naval experience coupled with his characteristic pa-

triotism prompted his notable activity in organizing the New York Commandery, Naval Order of the United States, of which he was a charter member and the Navy League of the United States. He was a member of the American Society of Naval Architects and Marine Engineers, American Society of Naval Engineers, Franklin Institute, National Geographical Society, Engineers' Club, Army and Navy Club and several others.

WILLIAM HARRISON CORBETT

William Harrison Corbett, President of the Williamette Iron and Steel Works, Portland, Oregon, died at his home in that city on February 20, 1911, after a brief illness. Mr. Corbett was born in Brooklyn, N. Y., on October 31, 1868, and was graduated from Stevens Institute in the Class of 1895. Before entering Stevens he had served his apprenticeship in the Rowland Machine Works, New Haven, Conn., and immediately upon graduation entered the field of mechanical engineering in New York City. In 1900 he removed to Portland, Oregon, to assume charge of the Williamette Iron and Steel Works, becoming President after the works were rebuilt some years ago.

Mr. Corbett followed the family trend as an iron manufacturer and ship builder, being the eldest son of Charles H. Corbett, Vice-President of the Continental Iron Works, and a grandson of the late Jeronemeus S. Underhill, one of the pioneer builders of iron vessels before the Civil War.

THE ECONOMIC IMPORTANCE OF THE FARM TRACTOR

By L. W. Ellis

ABSTRACT OF PAPER

The human race uses power for tilling the soil, manufacturing and transportation. Mechanical power in a large measure effected the removal of manufacturing from the home to the factory and the organization of land and water transportation on an unprecedented scale. Agriculture has been slow to accept mechanical power, because it has made better use of animal power. Capital necessary for the development of motive power for the farm has been occupied elsewhere and apparently inexhaustible soil fertility has enabled the old, inefficient methods to supply the demand for foodstuffs. Agricultural machinery has been developed with primary reference to the character of the power used. The engineer has had little to do with its design.

We now face a probable shortage of foodstuffs. Deeper plowing and better tillage must lay the foundation for greater yields. Only mechanical motors can supply the power for deep plowing without increasing the proportion of our crops needed to support the source of power. The tractor fits easily into the present farm scheme and solves many problems. It raises others and is almost certain to lead to the organization of the farm on a larger and more economical basis. Capital and brains are now concerned with the problem of cheaper production. There is a field for the mechanical or agricultural engineer in the rehabilitation of farm machinery, the development of farm motors, and on the larger farm itself, in the installation and superintendence of machinery and power.

THE ECONOMIC IMPORTANCE OF THE FARM TRACTOR

By L. W. Ellis,[1] La Porte, Ind.

Non-Member

Now, as in the beginning, the human race uses power for three great fundamental occupations: tilling the soil to produce materials; changing the shape of materials to adapt them for use; and carrying either the raw or manufactured product from place to place. In other words, power is required for agriculture, manufacturing and transportation.

2 Of these, agriculture, man's fundamental occupation, is the last to feel the need of mechanical power. In adapting animal power to human needs, the tiller of the soil has in all ages surpassed his contemporaries in the arts and commerce. But with animal power, even on the large farm, there has been little possible variation in methods and equipment from those of the small one. The possible manipulation of animal power by a single laborer quickly reaches its limit. Thereafter the increase in size of the farm is attended by increasing complexity of organization, involving more labor, deputized management and, usually, a decrease in efficiency as compared with the smaller holding.

3 With our present rural organization we are pressing on the limits of agricultural production. We are no longer exporting vast quantities of breadstuffs. We are earnestly considering the question of what we must do to be fed, and the problem of farm power overshadows all other factors involved in obtaining the answer. To provide permanently a sufficient supply of food, teachings of agricultural scientists must be universally heeded. Better seed, deeper plowing, more thorough tillage, must lay the foundation for greater

[1] Traction Plowing Specialist, M. Rumely Co.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

yields from each acre. Waste places must be reclaimed, our whole productive area developed and occupied. But our present needs are enormous, increasing more swiftly than these ideals can be realized. Greater areas must be brought immediately into productiveness and they must maintain maximum yields indefinitely, if production is to keep pace with demand.

4 The lack of power for plowing and harvesting is the tremendous obstacle to the sudden expansion into virgin fields of our productive area. The shallow plowing now generally practiced consumes 60 per cent of the total power expended in raising and harvesting the wheat crop, even on old land. Deeper plowing to secure maximum yields sharpens the necessity for power in the brief plowing season. The slow process of animal reproduction cannot respond quickly enough, and the price of horses has increased 143 per cent in ten years in spite of a 50 per cent increase in the supply. Today in Canada, where great added power is imperative, horses can be purchased only in limited numbers. Even the United States Department of Agriculture cannot find an adequate supply of brood mares for the future needs of the New South. Increased production cannot safely depend on animal power.

5 Nor is production the only consideration. Fifteen million work animals, and the 10,000,000 more to keep up the supply, scarcely develop sufficient power for present farm purposes. Their feed alone costs $1,250,000,000 per year, equalling the total income of 2,000,000 average families. Thus the crops from one acre in five are withheld from supplying human needs by the use of animals for farm power.

6 Cheap mechanical power on the farm can be made to combine the intensive culture of the small farm, well-tilled, with the economical production of the large farm, well-managed. It is already doing so on the immense sugar-beet ranches of California, where 10,000 acres of beets may be handled by a single management with specially designed engines and machinery. Dr. S. A. Knapp, of the Department of Agriculture, who is revolutionizing farm methods in the South, says that profitable farming has become a power and implement problem. Out of a gain of 200 per cent over the average crop he found better plowing and pulverizing of the seed-bed added 100 per cent; better cultivation, 50 per cent; and better seed, 50 per cent. Mechanical power need not impair fertility, as leguminous crops, gathering nitrogen from the air, can be plowed under more easily, and other animals can be kept which will produce human

food instead of power, and return to the soil manure of even greater fertilizing value.

7 For a quarter of a century mechanical power has taken the place of animal labor for operating stationary machinery on the farm. The small stationary gasolene engine of the last decade has relieved both man and horse of a host of minor duties. The automobile on many a farm has assumed the place of the light roadster and restricted the draft horse to the heavy work of the field. The farm field is the last and greatest stronghold of the horse, and the most difficult place for the substitution of mechanical power. But now, for large units at least the farm tractor has become a fixture.

THE FARM TRACTOR

8 The farm tractor is the solution of the immediate problem. Of all the sources of power it fits most easily into the present scheme of things. Excepting the thresher and the engine gang plows we have no field implements or machinery especially adapted to the use of mechanical power. The prime mover which shall take the place of the horse must therefore be capable of drawing implements designed for utilizing the horse's power, at least until other means of applying power to the soil shall have been developed.

9 The farm tractor does not age nor deteriorate when idle, and requires neither fuel nor attendance when not at work. The time spent annually in caring for a horse will keep the tractor in perfect working condition. It will endure heavy work 24 hours a day instead of 6, and outlive the average work animal in hours of service. It occupies less floor space than two wagons, and with a year's fuel supply may be sheltered in a building a tenth the size and cost required to house and maintain horses of equal power.

10 Efficient farm labor grows increasingly scarce. The tractor concentrates in one man's hands the power of 25 horses and the endurance of 100, and adds two-fold to the acres he can cultivate. By condensing crop operations within the period when the most favorable conditions prevail, it adds to the quantity and quality of the product. Every horse displaced by this new power saves five to eight more of these acres for human maintenance, for the mechanical motor consumes nothing which could be converted into food for mankind.

FARM MACHINES AND THE ENGINEER

11 The history of the average farm machine covers a period of cut-

ting and trying, of successive increase and decrease of the size of parts, of change of this and that, until every part is as strong and as light as the next. The great difference between the average farm machine and the celebrated "one-hoss shay" is that the latter was built to last for a century, while the former is built, first, to conserve power; second, to be sold at a low cost; and, finally, to last as long as it will. To meet the requirements of the situation, inventive genius, patience and perseverance have been needed, rather than high technical ability. Perhaps the latter was more than once tried and found wanting. Suffice it to say that McCormick, Deere and other great creative spirits were of the so-called practical type.

12 Machines of small capacity have had to be created for a hundred tasks formerly performed by hand. So frequent were improvements that until recently the durable machine might become obsolete before yielding a profitable return. The average field machine is in use but a few days each year, and a life of 500 working hours is probably above the average. High cost, then, is not justified and the American farmer likes to buy on price.

13 A mechanical engineer connected with the manufacture of farm engines once expressed his contempt for the self-binding harvester as a machine, and his admiration for the men who developed it. Said he, "Given the same problem, with his data on stresses and strains, his factor of safety, and his highly trained caution, the mechanical engineer would have produced a binder which would work and wear forever, but which would be so heavy, and cost so much, that a practical farmer would never hitch a team to it."

14 The character of the machinery man utilizes is determined largely by the type of power available for operating it. On the farm where the power needs are varied in the extreme, where during seedtime and harvest an enormous peak-load must be carried economically, the prevailing power has been one which required food, water and shelter, attendance and exercise 365 days in the year, a power which must be kept in constant readiness nearly 9000 hours for less than 1000 of service. The available power installation on the average farm has been therefore, a compromise between the amount required properly to do the work in two seasons of the year and the excessive maintenance charge imposed during the off-seasons. To reduce the peak-load has been the great problem, hence efficiency and durability of farm machines have only too often been sacrificed to the absolute necessity of light draft.

15 The tractor at the present time is much better in design and

execution than the average piece of farm machinery, and the handiwork of the mechanical engineer is to be noted in its make-up. However, even this field has been occupied largely by manufacturers trained in the usual school of experience. Many features of the present type of tractors are those of the investor rather than of the engineer with his facilities for editing the ideas of others. Ideas have come so thick and fast, the demand for tractors has been so great, and willing investors so numerous, that often only a single new idea has been necessary to call forth a working machine. Many are built around a single meritorious feature, the remainder of the machine being sadly out of balance. There are problems enough here not calling for inventive ability. There is the possibility of further refinement and greater efficiency in the steam tractors, perhaps the adoption of a system of superheating.

16 Centralization of farms and the shaping of farm processes to less extreme power requirements will take place slowly. There is therefore, the problem of the small tractor, both for universal use on the small farm, and for light work on the large one where a greater power unit is also employed.

17 Just now there is the type of tractor, which must be fixed; the best number of cylinders, speed of engine, tractive speed, size of drivers and distribution of weight; the kind and quality of materials and the best methods of construction. There is particularly the adoption of a practicable standard for rating tractors, the use of which would be of the greatest value to the non-technical purchaser.

18 The present offerings afford an ample basis on which to work out the final solution. Besides the wide variety of direct tractors, we have the cable-drawn implement with power stationary; the self-propelling machine, securing traction by grip on a cable instead of the soil; the machine with traction and working parts separate, the former operated by either animal or mechanical power, and the latter of rotary type, driven by mechanical power exclusively. The ultimate need is for a durable, self-contained plant, so light as neither to waste power in moving it, nor to compress the ground in passing over it, capable of performing every operation from driving a stationary machine to plowing, pulverizing, seeding, cultivating, harvesting and hauling the crop. It must be low in cost, both initial and operative, economical of labor and repairs, and capable of utilizing economically whatever fuel may be most abundant and easily procurable.

19 The success of mechanical power on the farm depends largely on an adequate supply of cheap fuel. The recent development of a

successful oil-burning tractor using the heavier, cheaper and more abundant grades of kerosene is a distinct achievement, a feat of tremendous importance in the advancement of this great movement in agriculture. The ultimate type of farm power will undoubtedly depend upon the acreage required to supply it with fuel, owing to the rapidly growing needs of the human race. The horse is capable of little further improvement in economy; the actual refinement of the tractor has scarcely begun. Here are problems for the engineer, the chemist and the agriculturist. The three, working hand-in-hand, can set forever at rest the question of our interdependent food and power supplies.

WHERE THE TRACTOR IS MOST EFFICIENT

20 The commercial efficiency of the present tractors is based largely on local conditions, such as the price of fuel, the accessibility and quality of water, cost of labor, topography, type of farming and volume of work. It is greatest in sections where they may be used for general farm work. This, for the larger and more common types, implies large tracts of land, and of course the lowest possible grades. The distribution of work on small grain farms favors the use of the tractor rather than the horse.

21 The cheapness with which the tractor breaks up virgin land and the simplicity of maintenance during idleness make for its use in the newer districts. The rapidity with which these sections are being settled is due quite as much to the use of mechanical power for plowing as to the extension of railway facilities.

22 In the colder climates, where all crop operations must be rushed and in climates where heavy work must be done under conditions of extreme heat the tractor naturally excels the animal. On the other hand, where work may be extended over long periods, and where corn, cotton and other inter-tilled crops require the use of a small power unit for cultivation, the lack of a small, flexible tractor favors the use of the animal. Even in these sections, however, the experiment station authorities unanimously maintain that depth of plowing and larger yields are commonly sacrificed because of a lack of power.

23 Three years ago, in a bulletin on traction plowing prepared for the Department of Agriculture, I stated that, taken as a whole, traction plowing could hardly be said to be cheaper than horse plowing, especially if gang plows were drawn by the horses. This was based on the observation that many operators used their engines only

for plowing and threshing, and the assumption that the average life of an engine would be about seven years. Both conditions are constantly being modified to reduce the overhead charges. Tractors are now used for plowing, discing, seeding, harrowing, summer fallowing, back-setting, harvesting, threshing and hauling, besides such jobs as running clover hullers, huskers and shredders, saw mills and the like. The volume of work provided becomes much greater as the tractioneer learns the possibilities of his outfit, and nearly every outfit now does some custom work.

STEAM VS. INTERNAL COMBUSTION TYPES

24 Moreover, improvement in durability and efficiency of both steam and internal-combustion tractors has been great, even in the short interval, and the compact engine-gang plows, now commonly used, are models of convenience as compared with the wide variety of types only recently employed. These quick changes have been forced upon manufacturers by the universal demand for better equipment for plowing. Schools of traction engineering, too, have aided much by increasing the efficiency of operators. Even if the earlier statement were still true, the question of cost is often a minor item, the net returns from a crop being dependent on the ability to perform necessary operations with a minimum of time. The capacity and endurance of the traction engine outweigh all other considerations in a crisis.

25 At western points distant from the refineries and close to coal fields and good water supply, steam engines may have the advantage of the internal-combustion type. In the nearer West the latter have come into use with a swiftness that is amazing when one considers that the first one to prove successful was launched only about eight years ago. Their economy in small sizes, their convenience, safety around buildings, and the fact that operators are not usually required to hold licenses, commend them strongly. Wonderful tank wagon service now brings fuel for the oil-burning engine direct to the farm at wholesale prices, an engine often yielding as great a profit to the refiner as a town of 600 inhabitants.

26 To date, no kerosene-burning tractor has achieved the thermal efficiency secured by the foremost gasolene tractors, but in all except the most remote districts the wide and growing disparity in fuel cost gives the former a marked commercial advantage.

27 The internal-combustion engine is economical of labor as compared with either steam or animal power. In plowing, for instance,

two men, with only occasional attendance by horses, are required for both engine and plows. For steam-plowing outfits I found an average of 6 men and 5.5 horses in California; 3.4 men and 3.1 horses in the southwestern states; and 4.2 men and 4.5 horses in the northwest. The engineer and plowman should be of the same caliber in either case, but the extra labor and board involved in operating the steam tractor is a serious handicap on small outfits. The capacity of the steam engines which as a rule are the larger, their fuel economy in some sections, and the fact that as a class they have been more reliable, have tended to equalize matters. The initial cost per horsepower is much less for steam than for internal-combustion tractors, but a somewhat greater outlay must be made in providing for the transportion of coal and water, and for the comfort of horses and extra men.

SOURCES OF DATA

28 The data which I have on the performance of tractors are largely from two sources, the agricultural motor competitions which have been held at Winnipeg and Brandon, Manitoba, and investigations which I conducted among every-day operators in connection with the United States Department of Agriculture. The former should be thoroughly reliable, but in some cases are open to doubt, the tests having been conducted hastily and without adequate facilities. The latter source is reliable only in that it averages the testimony of a large number of operators, few of whom had exact records. The tests conducted in the four motor competitions have been on the brake, first for economy, then for maximum power; in plowing, over firm, level prairie sod; and in hauling, over a half-mile circuit which presented almost every possible road condition from block pavement to loose gravel and mud. The various averages hereinafter presented are offered merely as a basis for rough comparison with the performance of motors used in other service.

COAL AND WATER CONSUMPTION

29 Table 1 shows the average coal and water consumption in the economy brake tests of steam tractors in Canada. It is not to be supposed that the load in every case was exactly at or even near the point of greatest economy, though this condition was usually aimed at. There was but 1 test of a compound engine on the brake, against

6 single and 11 double cylinder engines. In plowing there were 4 single and 6 double; and in hauling 1 single and 3 double.

TABLE 1 LB. OF COAL AND WATER USED PER DELIVERED H.P. PER HR.

TEST	SINGLE CYLINDER		DOUBLE CYLINDER		COMPOUND	
	Coal	Water	Coal	Water	Coal	Water
Brake.........	3.72	30.11	4.43	32.43	4.96	34.94
Plowing.......	7.46	52.8	8.87	69.0	....	.....
Hauling.......	14.18	114.6	12.84	91.1	....	.....

30 Steam tractors as a rule use from 7 lb. to 8 lb. of water per lb. of coal. Reports from 333 plowing engines of all types in the United States and Canada indicate an average of 7.67 lb. Twenty-four public brake tests show a mean of 7.78 lb.; 16 plowing tests 7.08 lb.; and 4 hauling tests 7.4 lb.; or a mean of 7.42 lb. for the 44 tests. Single cylinder engines show a range of from 5.78 lb. to 9.97 lb.; and double cylinder from 3.3 to 10.3 according to the official reports. Conditions were such however, as to arouse doubts as to the accuracy of such extreme figures. By making enough assumptions we can compare these data with those furnished by operators of 11 oil-burning steam engines in California. These men report the use of 9.4 gal. of water per gal. of oil. Assuming the oil to be of 20 deg. Baumé and to contain 20,000 B.t.u. per lb. they use 1990 B.t.u. in evaporating 1 lb. of water. The ordinary run of coal used contains not over 13,000 B.t.u. per lb., hence 1700 to 1740 B.t.u. would be furnished per 1 lb. of water.

GASOLENE CONSUMPTION

31 Table 2 gives an average of gasolene consumption in all public economy tests to date.

TABLE 2 GASOLENE CONSUMED PER DELIVERED H.P. PER HR.

TEST	1 CYLINDER		2 CYLINDERS		3 AND 4 CYLINDERS	
	No. Tests	Lb. Fuel	No. Tests	Lb. Fuel	No. Tests	Lb. Fuel
Brake.........	11	0.567	4	0.836	12	0.965
Plowing.......	6	1.273	4	2.076	9	1.778
Hauling.......	5	1.536	1	3.97	6	1.88

32 The average consumption for 27 brake tests is 0.747 lb., or a trifle over a pint per h.p-hr., the gasolene used being of 70 specific, 64 Baumé gravity. Nineteen plowing tests average 1.67 lb., and 12 hauling tests 1.91 lb., per drawbar h.p-hr. These averages are not comparable, but the matter of tractive efficiency will be discussed later.

33 The amount of water required per brake horsepower-hour by the internal-combustion motors depends largely on the cooling system. In these tests it ranged from 0 to 2.55 lb. per h.p. per hr., averaging in the neighborhood of $1\frac{1}{3}$ pints. A kerosene tractor, using water in the cylinders, consumed less than a pint of water per h.p-hr. The consumption by the evaporative type of cooler would in several instances have necessitated replenishment of the water supply after from two to three hours of heavy work.

THERMAL AND TRACTIVE EFFICIENCY

34 No analyses have been made of fuels used at the motor contests, hence the thermal efficiency of the various engines is in doubt. It probably ranges from 4 to 6 per cent for the steam tractors, and from 6 to 25 per cent for the internal-combustion type. Neither have tests been made of the boiler, mechanical or real tractive efficiency.

35 The fuel consumption in the brake tests bears direct relation to the number of cylinders. In the plowing and hauling tests the efficiency of the traction parts is brought also into play. Tests bringing out comparisons of the traction mechanism only have never been conducted, hence we are forced to use a crude comparison of fuel consumed and horsepower developed in the various tests. This topic deserves extended discussion, and Table 3 will serve to bring out only in a rough way the influence of various factors on tractive efficiency.

36 The small, single-cylinder motors had wheels much larger in proportion to total weight than the other classes, but more weight, also, per brake horsepower developed in the economy test. Comparing only the brake and drawbar horsepower they appear to have greater tractive efficiency than the larger and heavier machines. From the comparative fuel consumption however, we may assume that this was due rather to harder work of the engine, i.e., more brake horsepower was being developed during the plowing than during the economy brake tests. As previously stated, the road conditions were severe, every class developing in the hauling tests a lower per-

centage of the brake horsepower at the drawbar, and using more fuel per tractive horsepower-hour than in the plowing tests.

37 The light high-wheeled tractors with four-cylinder high-speed engines seemed to be much less affected by the adverse conditions, developing in either plowing or hauling about half as much tractive horsepower as brake horsepower, with approximately twice the fuel consumption per unit. The steam engines, with only a trifle more weight per brake horsepower than the four-cylinder gasolene tractors, and about the same height of drivers, but over 40 per cent more weight per inch in width of drivers, were able to turn this weight to good account in plowing on firm footing. Over the hauling course power dropped and fuel consumption rose in nearly the same proportion.

TABLE 3 TRACTIVE EFFICIENCY TESTS

Determined by Comparing Fuel Consumed and Horsepower Developed at Winnipeg, Man., July 1909

Type of Engine	Total Weight per 1 in. width of Driver	Weight per Economy B.h.p.	Drawbar h.p. / B.h.p.		Fuel per B. h.p-hr. / Fuel per drawbar h.p-hr.	
			Plowing	Hauling	Plowing	Hauling
Single-Cylinder, Gasolene, Low Wheel..	299	535	0.614	0.508	0.441	0.355
Four-Cylinder, Gasolene, High Wheel.....	407	416	0.531	0.499	0.538	0.533
Steam....................	585	456	0.566	0.293	0.499	0.344

Note.—This table includes four single-cylinder gasolene engines, three 4-cylinder, and four steam engines.

38 The drawbar pull of the gasolene tractors averaged about 17 per cent of the total weight in the hauling test and about 24 per cent in plowing. One horsepower was developed for 922 lb. of total weight. The drawbar pull of the steam engines was approximately 11 per cent of the total weight in hauling and 22 per cent in plowing. Averaging the two tests, the steam tractors have credit for 1 tractive h.p. for each 1033 lb. of weight.

39 This year the steam tractors delivered in plowing from 50 to 77 per cent of their economy load on the brake and from 37 to 58 per cent of their maximum. The dynamometer showed a mean resistance of 26 per cent of the total weight and 36 per cent of the weight on the drivers. The latter weight is probably only approximate.

A mean of percentages indicates that 73.5 per cent of the weight is borne by the drivers.

40 Seven internal-combustion tractors had a mean resistance of 25 per cent of the total weight and 35 per cent of the weight on the drivers, the latter carrying 70 per cent of the total. Data on a motor truck which overcame a resistance of 33 per cent of the total weight and 79 per cent of the weight on the drivers are excluded. This motor carries only 42 per cent of its weight on the drivers, and in the plowing test was loaded with human ballast to increase the percentage.

41 The rating of tractors is far from uniform, but steam ratings are more conservative than for internal-combustion engines. The brake rating of steam tractors is seldom less than three times the tractive or nominal rating. In tests this year every steam tractor not only exceeded both brake and tractive ratings, but developed a greater percentage of its maximum brake horsepower at the drawbar than was indicated by the ratio of tractive to brake rating.

42 Only two internal-combustion engines equalled their brake rating on the maximum test and only one its drawbar rating in plowing. The class averaged only 86.5 per cent of the brake rating on a maximum test, 80.9 per cent of the tractive rating on a semi-economy test in plowing and 80.9 per cent of their brake rating on an economy load. The steam engines exceeded the specified horsepower by 32 per cent, and the tractive rating 95 per cent, besides carrying 97 per cent of the rated brake horsepower on the economy load.

43 The daily capacity of a tractor depends on the width of the strip plowed or otherwise treated and the distance traveled. The former depends largely on tractive power. The character of machine drawn affects the distance traveled by governing somewhat the number of stops. Stops, however, are due more often to the necessity for taking supplies or making repairs.

44 The steam tractor formerly required a large amount of time for taking on supplies, but it is now easy to take water on the move, and, the transfer of coal, if sacked, is a small item. The internal-combustion tractor can usually travel a much greater distance without replenishing supplies than the steam tractor, though apparently little effort has been made to balance the capacity of fuel and water tanks. Were it possible entirely to empty either tank, nearly every internal-combustion tractor could travel 10 to 15 mi. under full load without stopping, while the average steam tractor requires a supply of water approximately once every 2 mi. and of coal every 5 or 6 mi.

DAILY CAPACITY OF TRACTORS

45 Sixty steam plowmen in the northwest average 1.48 mi. of furrow travel per hr., and 100 in the southwest average 1.5 mi. With internal-combustion tractors these were increased to 1.73 and 1.68 mi. per hr. respectively. These figures take account of all delays. Actually the traveling speeds are much higher. In one hauling contest, with no stops except for supplies, seven gasolene tractors netted 2.39 mi. per hr., or 92 per cent of the rated high speed, which averaged 2.59 mi. Four steam tractors netted 2.2 mi., or 86 per cent of the rated high speed. The previous year over the same course the gasolene tractors averaged 2.99 mi. per hr. One farm truck maintained 4.42 mi. per hr. with a load 50 per cent greater than its own weight. The same tractors which averaged 2.99 mi. per hr. in a non-stop haulage test averaged only 2.04 mi. of furrow travel per hr. in a plowing contest. The furrows in this case were short, necessitating many turns. Each turn takes from 45 sec. to 2 min., hence the net furrow travel was cut to 68 per cent of the hauling speed. Last year, with a longer course (120 rods) six gasolene tractors in plowing averaged in net furrow travel 74 per cent of the rated high speed and 80 per cent of their hauling speed.

46 This year, on a run of practically one mile, 97 per cent of the travel of one tractor was in useful work. The internal-combustion tractors this year averaged 1.86 mi. of furrow travel and the steam tractors 2.22 mi., in tests averaging about five hours. These are not far from the actual traveling speeds in difficult plowing, as there were few stops for supplies or turning.

COST OF OPERATION AND PRODUCTION

47 Comparisons of cost of operation are usually unsatisfactory, owing to the dominating effect of local conditions, and the personal element. Anywhere from 5 to 20 h.p-hr., may be needed to plow an acre. Ordinary loam shows a resistance of from $4\frac{1}{2}$ to $5\frac{1}{2}$ lb. per sq. in. of cross-section of the furrow slice, say 360 lb. for a furrow 6 in. by 12 in. In plowing an acre of this soil, the 12-in. plow will travel 43,560 ft. and require 7.9 h.p-hr. of work, in addition to the turns, etc. At Winnipeg it required from 12 to 19 h.p-hr. to the acre, plowed 4 in. deep. The transportation of supplies is a highly variable factor. In fact all factors are, and after trying for two years to

secure dependable averages, I was forced to generalize in a report dealing with the situation.

48 The manager of a noted Dakota farm this year puts the cost of producing an acre of wheat with horses at $8.45. A traction farmer in the same state produced a 2000-acre crop of flax last year for $6.56 per acre, allowing for all overhead charges. Roughly speaking, the tractor cuts ten cents from the cost of producing a bushel of wheat in a 20 bushel crop. Table 4 summarizes the comparative cost of production with horses and an oil-burning tractor for conditions in eastern North Dakota. Overhead charges on prime mover are included in the several costs of operations. Machinery costs for the tractor are a trifle higher because of the added investment in suitable plows.

TABLE 4 COMPARATIVE COST OF PRODUCTION

Cost of Production per Acre of Wheat	With Horses	With Tractor
Land rental	$2.00	$2.00
Plowing	1.35	0.76
Seed	1.13	1.13
Pulverizing and seeding	0.63	0.17
Twine and cutting	0.75	0.39
Shocking	0.22	0.22
Threshing	0.65	0.65
Machinery costs	0.62	0.67
Hauling	1.00	0.26
Incidentals	0.30	0.30
Total	$8.65	$6.55

49 The cost of keeping animals is increasing. The scarcity of lumber is making buildings for shelter more costly, Labor is higher in price, as is horse feed.[5] The average farm horse gets 10 lb. of food ($6\frac{1}{2}$ lb. of hay and $3\frac{1}{2}$ lb. of grain) for every hour he works, and some pasturage beside. His thermal efficiency is around 6 per cent when worked ten hours a day and skilfully fed, but ordinarily only around 1 to 2 per cent. Much of his work is light and he probably returns not over 500 h.p-hr. per year for the $100 which it takes to keep him. Other advantages than cost have given the tractor preference over the animal to date, but as the transition continues the comparative cost will vary increasingly in favor of mechanical power.

THE OPPORTUNITY FOR THE ENGINEER ON THE FARM

50 I have indulged in not a little prophecy, yet current events seem to indicate that it is not all idle. Mechanical power has come to the

farm and displaced the animal in countless instances. The old-time bonanza farms have largely been broken up into small holdings, on which the personal interest of the home-loving owner has proved more effective than the long-range management of the wheat baron. But a new type of large farm, owned by the stock company, managed by a scientifically-trained business farmer, and operated largely by mechanical power, is multiplying in the West. Men of means, for pleasure, perhaps, but also for experience and profit, are dabbling in farm ownership. The farm has been subjected to analysis by the soil expert, the chemist, the botanist, and pathologist, the plant and animal breeder, the economist, and, finally, by the business doctor. Now, for the first time, it is being analyzed as an engineering proposition, for after all these authorities have laid down the plan, the execution of it is largely an engineering problem. Thoughtful, far-sighted men have seen that the farm of the future will be one on which the efficiency of the equipment will largely measure the success of the enterprise. Four-year courses in agricultural engineering are already graduating men with a knowledge of civil, electrical, hydraulic, and most of all, mechanical engineering. The agricultural engineer must know something of all these branches, and more. He must know the problems of the farm; in short, must be an alert, well-equipped, all-round man. But his opportunity will be well worth the necessary training. He will install machinery, erect buildings, plan the water supply, irrigate or drain as the case may be, superintend the maintenance and perhaps the operation of all equipment. His life will be in the open, with all the conveniences and opportunities for mental development that the modern farm will afford. His will be an honored profession, his career a constant stimulus to breadth of vision and intellect.

COMMERCIAL APPLICATION OF THE TURBINE TURBO-COMPRESSOR

By Richard H. Rice

ABSTRACT OF PAPER

The paper describes a compressor unit for blast furnace work consisting of a four-stage Curtis steam turbine direct-connected to a six-stage centrifugal compressor. This was built and installed at Oxford Furnace, N. J., by the General Electric Co., and is the first of this type of apparatus to be made in this country. It is governed automatically by mechanism which depends for its action upon a change in the rate of air flow, by which means the speed of the turbine is varied as required. The governor regulates the volume of air delivered per minute so as to keep the rate of discharge constant at the value determined by the furnace superintendent. It is found that on account of the steadiness of operation and more uniform conditions the output of the furnace has been increased and it is concluded that, considering all the factors, the centrifugal compressor as a blowing apparatus can be operated at a lower net cost than any other means for blowing furnaces. The paper contains data upon sizes and capacity of the apparatus with diagrams showing the characteristics of its performance.

COMMERCIAL APPLICATION OF THE TURBINE TURBO-COMPRESSOR

By Richard H. Rice, West Lynn, Mass.

Member of the Society

The General Electric Company recently put in operation at the Oxford Furnace, N. J., plant of the Empire Iron & Steel Company, a turbine-driven air compressor (Fig. 1) for blowing the blast furnace, which is the first installation of this type of apparatus to be made in this country.

2 The unit consists of a six-stage compressor operating at a normal speed of 1650 r.p.m. and driven by a direct-connected four-stage Curtis steam turbine. The design is such that this normal speed produces a blast pressure of 15 lb. per sq. in. The unit, however is designed to regulate the volume of air delivered per minute so as to keep the rate of discharge constant at any value, determined by the furnace superintendent, within its capacity. The manner in which this is accomplished will be fully described in the sequel, but it may be said here that the regulation is by means of speed variations, so that the machine is a constant-volume, variable-speed apparatus, and not a constant-speed as in other classes of blowing units.

3 The compressor has six stages arranged in series, so that the air enters at the end nearest the steam-turbine driver and passes successively from stage to stage until it reaches the other end of the compressor casing, where it enters the discharge pipe. The impeller wheels are so designed that there is no unbalanced end thrust, so that the ordinary means used in the Curtis turbine for locating the rotating elements and preserving proper clearances are sufficient for the entire apparatus.

4 The air is cooled in each stage during compression and also in passing between stages by suitable water chambers in the diaphragms, and this cooling is sufficient to maintain the compression approximately along the adiabatic line.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

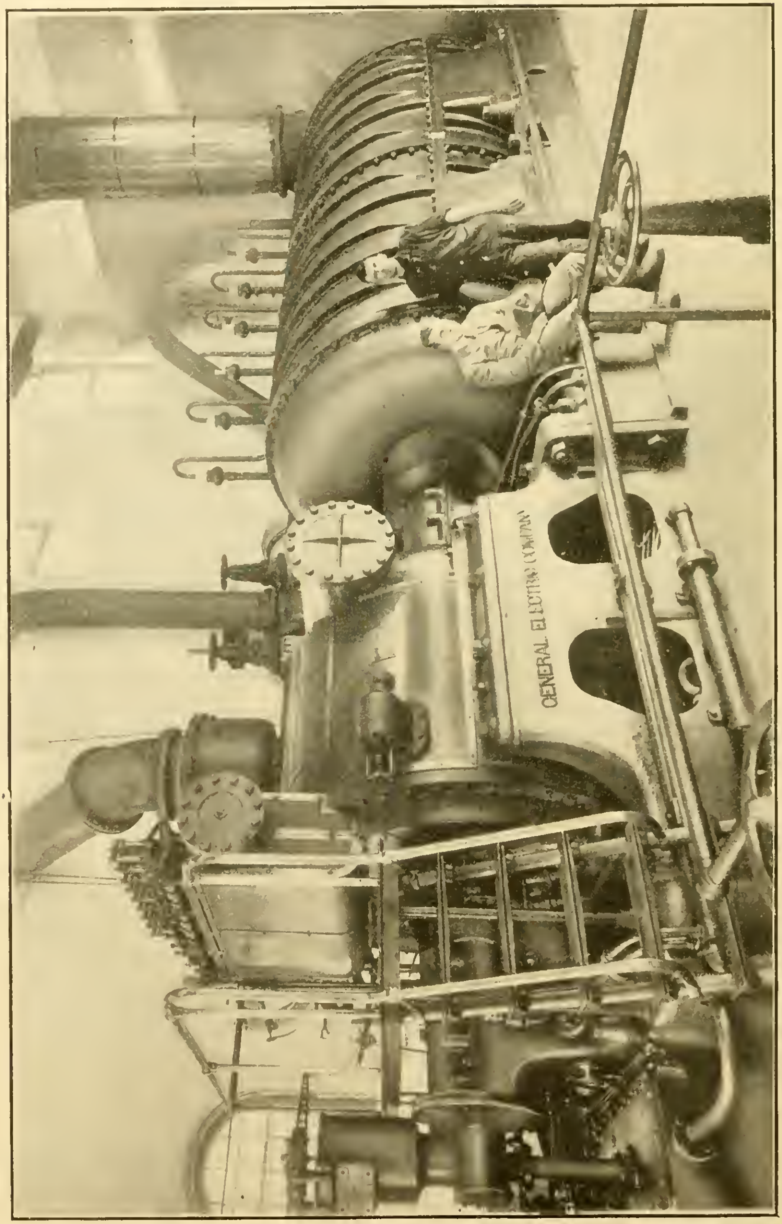

FIG. 1 AIR COMPRESSOR DIRECT-CONNECTED TO CURTIS STEAM TURBINE, 1500 R. P. M. EMPIRE IRON & STEEL CO., OXFORD FURNACE, N. J.

5 No valves or rubbing surfaces are used in the compressor construction and, as in the turbine, the rotating elements revolve freely with ample clearance so that no wear or deterioration can take place; therefore, the efficiency of compression must remain constant.

6 Fortunately, both turbine and compressor attain their best efficiency under similar conditions as regards rotating speed, making the combination a logical and efficient one. Under conditions usually met with in blast furnace operation involving pressures of blast of 10 to 20 lb. per sq. in., the efficiency remains sensibly the same. A

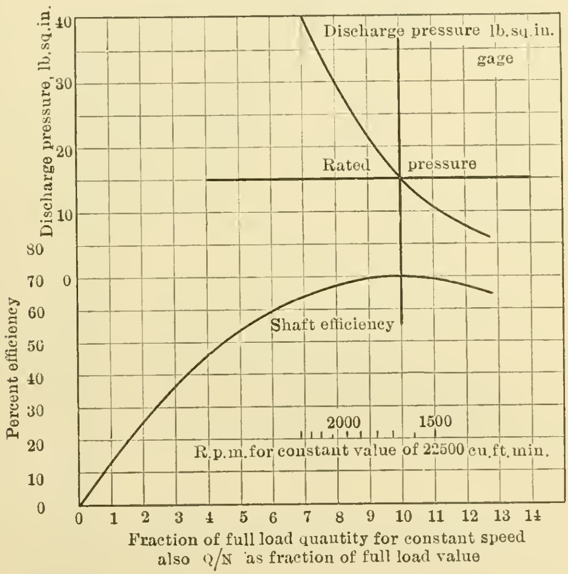

FIG. 2 EFFICIENCY AND PRESSURE CURVE WITH CONSTANT-VOLUME GOVERNOR. COMPRESSOR WITH SIX STAGES

curve of efficiency at varying volumes is shown in Fig. 2 and above this has been drawn a curve of speeds and pressures which, taken in connection with the first named curve, shows the variations of efficiency with pressure, at rated volume.

7 This latter curve shows graphically the variation of pressure with change of speed, which follows the law of squares; that is, doubling the speed gives four times the pressure, etc., from which it will be seen that only moderate changes in speed are necessary to give considerable changes in pressure. It is these changes in speed, increasing or decreasing the blast pressure, which are utilized to main-

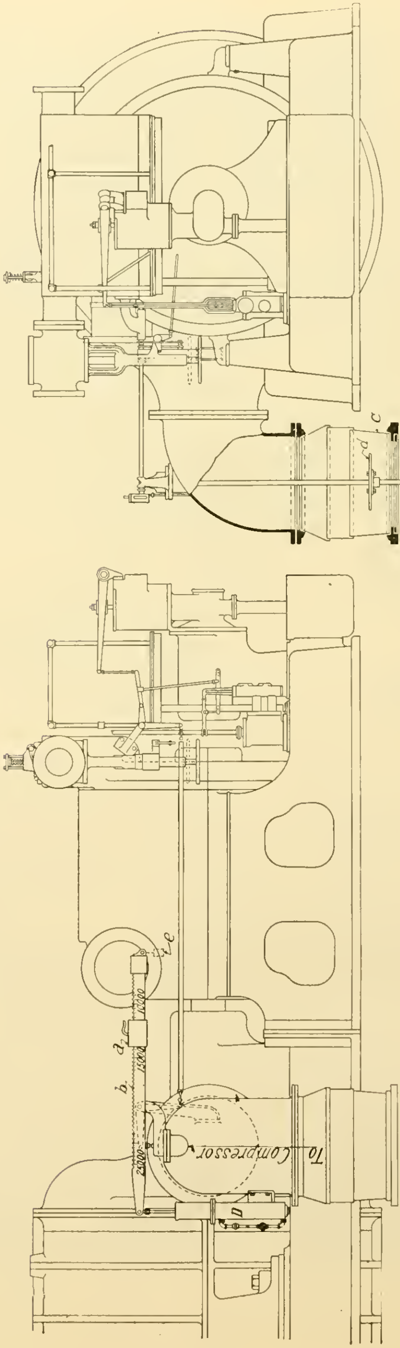

FIG. 3 VIEW SHOWING CONSTANT-VOLUME GOVERNOR

tain a constant rate of flow of air into the furnace, against the varying resistances set up in the tuyeres and furnace by varying furnace conditions; as, for instance, clogging of tuyeres and changes in the size and composition of the charge, temperatures, etc.

8 The means by which these changes of speed are produced in the manner necessary to keep up a constant rate of influx of air per minute is shown in Fig. 3. This shows a steel disc *d* sustained on the inflowing air current within a conical enlargement of the inlet pipe. By means of the sliding weight *a*, the resistance of this float and displacement by the air current is adjusted in accordance with a scale on the scale beam *b* which is graduated accurately in cubic feet per minute to read volumes of free or atmospheric air. By setting this weight at the graduation corresponding to the rate of discharge of air desired, the disc is caused to assume a position in the conical enlargement *c*, which results in supplying steam to the turbine in quantity sufficient to establish the proper speed of the compressor and pressure of blast to cause the required flow of air through the furnace. In case the rate of air flow tends to decrease, the disc *d* sinks to a lower point in the enlargement *c*, since the supporting air current decreases its sustaining power. More steam is by this admitted to the turbine and the speed is increased, resulting in increase of pressure, and this increased pressure reëstablishes the desired flow of air. In case too much air tends to flow into the furnace, the reverse of all these effects takes place. In practice, the operation of this device is most regular and satisfactory.

9 This method of governing, by the indications of a properly calibrated scale beam, gives an entirely new instrument, which, in the hands of a skilled furnace manager, will undoubtedly enable improved results in furnace operation to be obtained, since an accurate knowledge of the amount of air supply is always at hand by this means.

10 Such knowledge cannot be obtained from reciprocating blowing engines, since the expansion of air in clearance spaces causes an error increasing in amount as discharge pressure increases, and because leakage increases with increase of discharge pressure and the slip is a variable and uncertain amount. On the contrary the air governor is unvarying in its action, and will not change its indications with time, since wear and leakage are absent.

11 It has been intimated before that this is a variable-speed apparatus. In normal blast furnace operation pressure may vary from 10 to 20 lb. per sq. in. These pressures require speeds in the particular apparatus under description of about 1500 for 10 lb. pres-

sure to 1800 for 20 lb., as appears on the curve, Fig. 2. The blast furnace operator therefore instructs the engineer operating the compressor not to maintain a certain number of revolutions, as is customary with reciprocating engines, but to set the scale beam weight for the required volume in cubic feet per minute.

12 The graduation and calibration of the scale beam in cubic feet per minute is determined during the shop test of the apparatus before shipment by accurate tests with standard orifices and pitot tubes and these graduations are accurate within about two per cent.

13 A simple oil dashpot *D*, Fig. 3, attached to the scale beam, prevents any racing or undue fluctuations of speed.

14 In operating the blowing unit, it is only necessary to manipulate the hand throttle valve in the main steam pipe when it is desired to bring the compressor to rest. At all other times control is effected through the scale beam, with wide-open throttle. At times of checking the furnace or casting, the weight *a*, Fig. 3, is moved to the extreme end of the scale beam at the position indicating the minimum volume for which the scale beam is graduated, and still further decrease of speed and pressure is produced by adding an auxiliary weight at this end of the beam or by depressing it by hand. On removal of the auxiliary weight and replacement of the sliding weight *a*, at the running volume graduation, the compressor speeds up until the volume required is obtained. This manipulation is in practice of the simplest character.

15 The air governor acts upon the pilot valve of the hydraulic valve gear commonly used on the larger sizes of the Curtis turbine, through a system of floating levers, in such wise that when the turbo-compressor nears the maximum speed for which it is designed, in this case 1950 r.p.m., a centrifugal governor of the usual type comes into action and keeps the speed at this maximum as long as the resistance to air flow in furnace or tuyeres remains so high that the volume of air, for which the air governor is set, cannot be forced through at the maximum pressure to which this speed corresponds, in this case 25 lb. per sq. in. During this period the air governor is out of control of speed, but it comes into action immediately when the furnace resistance decreases.

16 In case of breakage or sticking of the governor mechanism which permits the speed to exceed 1950 r.p.m., an emergency governor mechanism, entirely independent of the mechanism previously described, comes into play and closes the main throttle valve, bringing the compressor to rest.

17 In all high-speed apparatus the certainty of the oil supply is an important feature and it is particularly so in this service. In this unit there are three shaft bearings requiring automatic lubrication, and this is furnished by a valveless gear pump, worm-driven from the main shaft, which circulates oil under 15 to 25 lb. pressure. The same pump also supplies this necessary oil to the hydraulic cylinder which actuates the valve gear. The oil is returned from bearings and cylinder to a tank where it is settled and strained before re-use. In order to guard against any stoppage of oil circulation, an alarm is provided which causes a steam whistle to blow in case the oil pressure falls to 5 lb. per sq. in.

18 The oil is cooled in the bearings at the point where the heat is generated, by means of water-cooled coils embedded in the bearing linings.

19 The apparatus described uses, of course, high-pressure steam. Obviously the compressor is adapted equally well to the use of low-pressure turbines as to drivers and so driven affords a ready means of increasing the efficiency of existing plants containing reciprocating blowing engines, by the usual method of exhausting from the reciprocating steam cylinders into the low-pressure turbine. The governing by volume of air discharged is equally applicable here, and all the advantages of this system can therefore be realized.

20 Increased efficiency of the plant to the extent of 20 per cent to 50 per cent may be thus realized with a very moderate addition to the cost.

21 The installation at the Empire Iron & Steel Company, which the photographs accompanying this article represent, was put in operation on the furnace on March 8, 1910, and has been in continuous operation ever since. At the time this apparatus was put in operation, it was not expected that the volume of air required by the furnace would be at such a low figure as turned out to be the case, the machine having been designed for a normal volume of 22,500 cu. ft. per min. On putting the machine on the furnace, it was found the volume required was only about 15,000 cu. ft. per min. and the pressure corresponding to this volume under furnace conditions ranged from 10 lb. to 12 lb. Under these conditions, it was found that pulsations were met with in the pressure line, this pressure fluctuating about 2 lb., and in order to overcome this pulsation it was found necessary to throttle the inlet opening. Fig. 4 shows the character and magnitude of these pulsations. Since this time, a convenient butterfly-valve throttling mechanism has been designed and

applied, which is found to eliminate these pulsations without appreciable loss of efficiency.

22 The pulsations in pressure above noted are an inherent characteristic of all centrifugal blowing apparatus of similar construction, and they occur when the apparatus is operated at loads and pressures widely differing from those for which the apparatus is designed; that is, from normal full volume and pressure. At any given volume they occur at a certain critical pressure and at all higher pressures, but do not occur at lower pressures than the critical. As volume is increased, critical pressure increases also. The critical pressure is slightly affected by the density and the humidity of the air.

23 Fig. 5 gives the characteristic critical pressure-volume curve of this compressor.

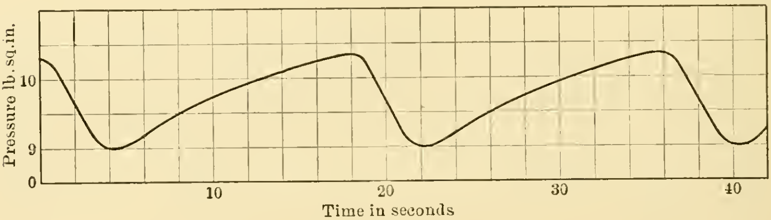

FIG. 4 PRESSURE CURVE DURING PULSATIONS

24 The rate and extent of the pulsations are affected by the capacity of the discharge piping, stoves, etc., into which the air flows. The larger the capacity the longer the period or wave length and the greater the wave magnitude, and vice-versa. The diagram in Fig. 4 shows the pressure waves from the machine installed at Oxford Furnace. When tested in the shop with very short piping of small capacity, the wave length was only a second or so, and of very small height.

25 The pulsations occur only at such loads that the characteristic pressure curve of the apparatus is rising with increase of volume or remains horizontal, and the effect of the throttling is to superpose a drooping pressure curve, falling with increasing volume, which alters the shape of the resultant pressure curve and makes it droop also. As the throttling required to remove entirely such pulsations is only a few inches of water, it has no appreciable effect on the efficiency of the compression.

26 Fig. 6 is the curve of pressure and volumes for this compressor at *constant speed.*

27 At the time this was written the blast pressure at Oxford Furnace varied from 10 lb. to 14 lb. during the day with volume constant at 16,000 cu. ft. per min. The speed varied from 1500 to 1600 r.p.m. The average steam pressure was 135 lb.

28 The figures in Table 1 are taken from a typical station log, showing the variation of pressure and volume during the 24-hr. period of operation.

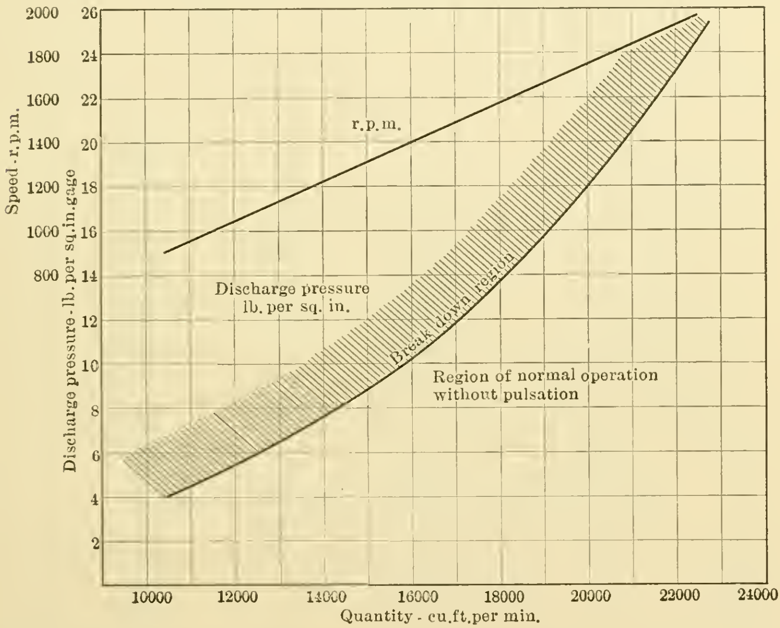

Fig. 5 Curve of Breakdown Points from Factory Tests. Pressure and R.P.M. Plotted against cu. ft. per min.

29 The apparatus used for blowing the furnace before putting this machine into operation consisted of two vertical reciprocating blowing engines built by the I. P. Morris Company, each of the following dimensions: Steam cylinder diameter, 54 in.; blowing cylinder diameter, 72 in.; stroke, 72 in. Blowing cylinder displacement, 339 cu. ft. per revolution each. Maximum speed rating, 30 r.p.m. each, giving 20,300 cu. ft. per min. total displacement. Actual maximum

speed, 23 r.p.m. each, giving 15,000 cu. ft. per min. total displacement. The average blast pressure was 8 lb.

30 Judging from the revolutions of this engine, it was thought that the volume used was about 14,500 cu.ft. On putting the centrifugal compressor into action, an immediate increase in the amount of iron melted by the furnace was experienced. The output went up from an average of 139 tons per 24 hr. in February 1910, to 176 tons in April 1910, and the iron was found to be of a more uniform character and the operation of the furnace was improved. A gradual increase in the amount of air has since taken place and the corresponding increase in pressure required to force the air through the furnace has

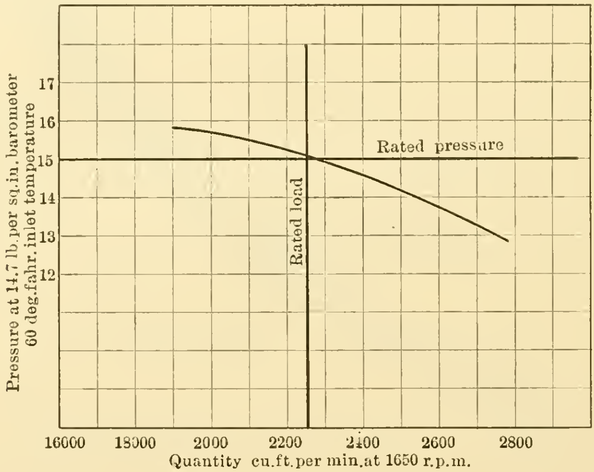

Fig. 6 Factory Test, Showing Pressure Plotted against Quantity of Air. 1650 r.p.m.

been necessary as was to be expected. This increase of air has resulted in an increase in the production of the furnace from 176 tons on starting to the present average of about 190 tons. The machine is now operating with 16,000 cu. ft. of air and the production of ore is 185 tons per 24 hr. average. It is proposed to continue this increase to 200 tons per 24 hr., the limit of the charging apparatus.

31 The dimensions of the furnace are as follows: Diameter at bosh 17 ft. 6 in.; at hearth 11 ft.; at top throat 12 ft.; height from hearth to dumping ring 80 ft.

32 The condensing apparatus is of the barometric type, and the injection water is supplied by a turbo-driven centrifugal pump, placed

in the sub-basement; and at the outset when the machine was first put in operation, difficulty was encountered with the condensing water supply, which made it necessary to operate the machine for a considerable period of time non-condensing. Owing to the unfamiliarity of the fire-room force with the new boilers which had been installed it was even necessary to operate with steam pressures as low as 60 lb. per sq. in. gage for various periods, under which conditions the compressor set operated with entire satisfaction.

TABLE 1 ENGINE ROOM REPORT, MARCH 17, 1910

EMPIRE IRON & STEEL COMPANY, OXFORD FURNACE, N. J.

Time	Volume, cu.ft.	Blast Pressure, lb.	r.p.m.	Steam Pressure, lb.	Vacuum, in.
a.m.					
1	15750	13	1540	140	24
2	15750	12.5	1490	135	25
3	15750	13.5	1580	135	25
4	15750	12	1510	140	24
5	15750	13.5	1530	155	24
6	15750	13	1550	150	25
7	15750	12.5	1550	150	25
8	15750	12	1490	120	h.p.
9	15750	11.5	1500	130	h.p.
10	15750	13.5	1580	160	26
11	15750	12.5	1520	155	26
12	15750	12.5	1500	150	26
p.m.					
1	15750	13	1530	140	26
2	15750	12	1490	150	26
3	15750	13	1560	130	26
4	15750	13	1560	150	26
5	15750	11	1445	145	26
6	15750	11.5	1450	130	26
7	15750	11	1490	135	26
8	15750	13	1510	140	26
9	15750	12.25	1500	155	25.5
10	15750	11	1383	140	25
11	15750	11.5	1410	150	25.5
12	15750	11.5	1440	145	25

Made 208 tons of iron in 24 hours.

33 Owing to the fact that the condensing apparatus is of the barometric type, the further fact that the machine is operating far below its designed capacity and the difficulties involved in making an accurate boiler test to determine the amount of feed water under present conditions, no tests have been made to determine the actual efficiency of the machine. It is, however, furnishing considerably more air than the old machines, as is evidenced by the greatly increased product of the furnace, and is at the same time operating with fewer

boilers. Also these boilers are more easily worked than when operating with the engine.

34 There is great difficulty in making comparisons of the performance of this type of blowing unit with reciprocating types, either steam or gas driven, owing to the absence of actual test figures, since none have been published which permit of accurate and satisfactory comparison. With the results which have been obtained from all sources as to the actual performance of such machines and from actual experience with this machine and its sister machine installed at the Northern Iron Company, in line with tests which have been made in the factory, it seems that the following conclusions are correct in reference to this apparatus as compared with reciprocating engines for blowing blast furnaces:

a That the output of the furnace is increased on account of the greater steadiness of operation and more uniform conditions obtaining in the furnace.

b That the quality of the product is improved.

c That the steam consumption is equal to, or less than, that of the best compound engines blowing similar furnaces.

d That the engine room space occupied is only a fraction of that needed by reciprocating engines, either steam or gas.

e Considering all factors, including consumption of fuel; cost of operation, including oil and supplies, attendance, etc.; cost of buildings and foundations, interest on the investment; and cost of maintenance of plant; that the centrifugal compressor is a blowing apparatus which can be operated for a lower net cost than any other means of blowing furnaces.

THE PURCHASE OF COAL

By Dwight T. Randall

ABSTRACT OF PAPER

Most boiler rooms are now conducted in a manner which permits of considerable saving along two lines: (*a*) the selection of a coal which is suited to the plant and at the same time is capable of delivering the greatest amount of heat to the boiler for a unit of cost; (*b*) burning the coal by approved methods to obtain the highest practical efficiency.

The coals which are offered in almost any market vary in price and in quality to an extent which justifies a careful study of their character and heating value in order to determine which coal will prove most economical when the equipment, the load conditions and the price are considered. A coal which is entirely satisfactory in one plant may be unsuited to another.

It is possible to burn almost any fuel with reasonably good efficiency provided the furnace is properly designed for the particular fuel to be burned.

Coals which are suitable for any given equipment depend for their value principally upon the B.t.u. and the size of the coal. A thorough study of coals and the variations in their quality has naturally led to the purchase of coal under specifications with a guaranteed analysis, which provide for a definite procedure in case of a variation in the quality of coal delivered.

THE PURCHASE OF COAL

By Dwight T. Randall, Boston, Mass.

Member of the Society

Large savings may be made in the boiler room along two distinct lines: first, by burning the fuel at the highest practicable efficiency; second, by choosing fuel of a character suited to the plant conditions and equipment and which at the same time will develop the greatest amount of heat for a unit of cost. Each locality and each kind of equipment presents a different problem for solution.

VARIATIONS IN THE QUALITY OF COAL

2 The coals of the United States vary widely in their character, some being high in fixed carbon and low in moisture, volatile matter and ash, while others are low in fixed carbon and high in other constituents. Moisture is an inherent constituent of the coal and an increase in its percentage decreases the heating capacity of a given coal proportionately. This constituent is weighed and paid for on an equal basis with the combustible portion of the coal, and therefore this determination is of considerable importance in ascertaining the value of coal.

3 An analysis reported "as received" represents the composition of the coal just as it is delivered at the laboratory. An analysis reported on the "dry basis" represents the composition of the coal after having been dried for one hour at 105 deg. cent. in a special oven. Coals containing low percentages of volatile matter may be burned in ordinary furnaces with good results, but those with high volatile matter give off large quantities of gas and are difficult to burn with economy and without smoke except in furnaces which are specially designed.

4 The ash in coal is, like moisture, an inert constituent. The ash may be present in the coal in small particles distributed in such a way as to make it impossible to separate it from the coal, or some of

it may be present in larger pieces which, owing to a lack of care in mining and preparation, are often found in the coal as it comes to the market. Not only does the percentage of ash in coals affect their value, but the nature of this ash may influence the efficiency with which coals are burned. Increased percentage of ash also decreases the heating value proportionately and causes additional expense and loss in efficiency due to extra labor required to handle this ash, both on the grates and when it is removed. The fusibility of ash governs the percentage of clinker that will be formed from any type of coal and consequently some attention should be given to this feature. Sulphur is found in varying percentages and is generally considered an undesirable element.

5 The B.t.u. or heating value of coals of any given type determine directly their value as fuels. When coals of the same character are under consideration the heating value may be considered as a correct measure of the value of the coal. When coals of different character are to be compared, the character of the coal as well as the heating value must be considered.

6 There is often a considerable variation in the quality of coals from the same district. This is due principally to the impurities which are found in the coals. Mines that are working the same bed of coal at points which are near each other often deliver coal having different values on account of variations in the coal itself or in the methods of mining and preparing the coals for the market.

7 On account of economy in mining and in marketing coal, it is a very common practice for one company to operate a number of mines and to ship coal from all of these mines to their customers. It is only rarely that coal is equally good in all the mines and, therefore, the customer will receive some good coal and some inferior coal. This is also true of the coal which is sold in barge lots. A large number of carloads of coal are required to fill the barge and it is not practicable in many cases to furnish the coal from one mine.

8 Some coals may be burned at high or low rates of combustion without difficulty and with good efficiency, but there are many coals which always give trouble from clinker when burned at high rates of combustion. When burned at moderate rates they may usually be fired so as to give the same percentage of heat to the boiler as the non-clinkering coals.

RELATION OF QUALITY TO RESULTS

9 The influence of the volatile matter on the efficiency depends on the design of the furnace. With a poor furnace and indifferent firing the coals containing about 18 per cent volatile matter may give results 10 or 12 per cent higher than coals containing 30 per cent or more volatile matter. With furnaces adapted to the kind of coal burned there is but little loss of combustible gas.

10 The ash in the coal affects the heating value to some extent as there is a loss of both time and heat while the fires are being cleaned and the presence of large quantities of ash interferes with the proper distribution of air through the fuel and may lower the efficiency.

11 The moisture not only requires heat to evaporate it into steam, but if the coal is very wet and is fired in large quantities, it may cool the bed of fire and cause an additional loss of unburned gas.

12 The size of coal is important in many cases. If the coal does not coke and is fine, there may be a large loss of fuel through the grates when burned on inclined grate stokers or on hand-fired grates at rates that require frequent breaking up of the fuel bed. The size of the coal also affects the economy with which it may be fired. If coal is too large more air is admitted than is necessary to burn it properly and if the fuel bed can not be increased in thickness to overcome this difficulty, there will be a large heat loss. If the coal is fine and the draft is very strong, some of it will be carried off the grate only partially burned. This is frequently the case when the coals are fine and light and the boilers are forced.

13 Fine coal which cakes and forms a porous coke may be burned with good efficiency. If the coal does not coke but packs closely on the fuel bed, it is difficult, if not impossible, to secure a uniform air supply at all parts of the bed and the combustion is poor owing to an excess of air at some points and a lack of air at others.

14 Fuels considered without reference to any particular equipment may be valued on the basis of their available heating value. It has been found possible to design furnaces to burn almost any fuel with reasonably good efficiency when based upon the available heat of the fuel. This has been accomplished with tan bark, sawdust, lignite and low grade coals. As a rule inferior coals can be bought much more cheaply on their heating value than the higher grades of coal and it is to the interest of every consumer to select the coal which will give the greatest amount of heat from a unit cost, provided it can be burned successfully in his plant. In many cases it will be

profitable to change the equipment so as to burn slack coal or coals which are below the average quality. It is fully as important to take into account the size and character of coal when automatic stokers are in use as when the coal is hand-fired.

15 The same intelligence should be used in selecting coal for a given use as is required in selecting steels for manufacturing purposes. Some of the most progressive users have been aware that there was a considerable difference in the quality of the coals used in their plants and have generally decided that the chemical analysis, with determinations for heating value, is the best basis on which to establish a standard.

16 The methods employed in burning the coal are of equal importance with the quality and should be given careful attention. The coal dealer should not be held responsible for results in boiler plants except as influenced by changes in the quality of the coal delivered. A coal which is suited to one plant may not burn well in another, owing to differences in equipment, load condition or to the methods of handling the fires.

17 The advantages of knowing accurately the quality of coal which is being burned in a power plant and whether any changes in the coal consumption are due to the coal or to the method of operating the plant, have led a number of managers to make analyses of all the coal delivered to their plants. After following the deliveries in this way for a year or more, these men have as a rule decided to place their contracts with the understanding that if the coal delivered can be prepared so as to eliminate more of the impurities, they will pay a higher price, and if the coal is below quality they will deduct from the regular price in accordance with the quality of the coal.

18 Immediately on considering the purchase of coal on a guaranteed analysis the question as to how the sample shall be taken and by whom it shall be analyzed is raised. The method of taking a sample of coal is fully as important as the manner in which it shall be analyzed and the cause of doubt as to the value of coal analyses has been largely due to ignorance or carelessness in taking samples for analysis. It is only fair to both parties concerned that the sample should be taken in the manner which will secure a small portion which is thoroughly representative of the entire lot. A method has been quite generally adopted and experience has shown that when two samples are taken in accordance with these approved methods the results are within reasonable limits of accuracy.

METHODS OF SAMPLING

19 The following method of obtaining a sample of coal has been used by a number of different firms and has been found satisfactory. The main object in taking a sample of coal is to secure a small portion of the coal which represents as nearly as possible the entire shipment or delivery.

20 The original sample should preferably be collected in a large receptacle with cover attached, by taking small shovelfuls from many parts of the car, barge or vessel as it is being unloaded, or from as nearly all parts of a pile as possible, care being taken in all cases to secure practically the same amounts from the top, middle and bottom of the coal. The original sample thus taken should amount to 500 lb. or more, preferably 1000 lb. to 2000 lb. A separate sample should be taken from each 1000 tons or less delivered. The gross sample thus collected should contain the same proportion of lump and fine coal as exists in the whole shipment. It should be protected from the weather in order to avoid gain or loss in moisture and should be immediately quartered down to a smaller sample, according to the following method.

21 The large lumps of coal and impurities should be broken down on a clean, hard, dry floor with a suitable maul or sledge. The coal should be thoroughly mixed by shoveling it over and over and formed in a conical pile. The pile should then be quartered, using a shovel or board to separate the four quarters. Two opposite quarters should then be rejected and the remaining two broken down to a smaller size, mixed and re-formed in a conical pile and quartered as before. This process should be continued until the lumps are ¼ in. in size or smaller and a one or two-quart final sample remains. *All* of this final sample should immediately be placed in one or more glass or metal cans and sealed air tight. The following table gives the largest sizes allowable in the samples of various weights and the coal should preferably be broken into still smaller sizes before quartering:

Weight of Sample	Should Pass Through
1000 lb. or over	1½-in. sieve
500 lb. or over	1¼-in. sieve
250 lb. or over	1 -in. sieve
125 lb. or over	¾-in. sieve
60 lb. or over	½-in. sieve
10 lb. or over	¼-in. sieve

22 The sample should be worked down as rapidly as possible to avoid loss of moisture through exposure to the air. The outside of the can should be plainly marked and a corresponding description placed inside the can.

23 The following data should accompany the sample:

Coal delivered to..
Sampled by............................Date.......................
Amount taken for original sample..
Amount of coal sample represents..
Sampled from barge, car or pile...
Car (initial and number) ....
Barge or vessel...
Trade name of coal..
Grade ($\frac{3}{4}$, slack, nut, run of mine, etc.)................................
Remarks (appearance of coal, lumps, slate, sulphur balls, weather conditions, etc.) ....
Sold by..................................Mined by..................
County.....................State ....Mine ....

ACCURACY OF SAMPLING

24 It is difficult to make the average man understand the importance of the sample and the influence of the method of sampling on the results. The methods and care used in breaking down and quartering the sample are very important.

25 Some figures are submitted to illustrate this point. An experienced sampler was instructed on three occasions to take samples of coal from a barge and to take a duplicate sample from the opposite quarters in addition to the regular sample. Analyses of these samples (Table 1) showed that the results were well within reasonable limits for the combined error of sampling and testing.

TABLE 1 ANALYSES OF DUPLICATE SAMPLES BY EXPERIENCED SAMPLER

	Sample No. 1		Sample No. 2		Sample No. 3	
	No. 1A	No. 1B	No. 2A	No. 2B	No. 3A	No. 3B
Weight of sample, grams	958	830	864	680	832	827
Ash in dry coal	7.80	7.75	7.98	8.16	7.62	7.57
Sulphur	0.98	0.93	0.92	0.87	0.90	0.92
B.t.u.	14,539	14,528	14,478	14,423	14,549	14,600
Difference		11		55		51

26 To illustrate the results of careless preparation the following data are submitted. A man with but little experience in sampling coal, but who had been instructed as to the proper methods was told to sample about 500 tons of coal and on making the final quartering to place each of the quarters in separate cans. These cans were then sent to the laboratory with the results shown in Table 2.

TABLE 2 ANALYSES BY INEXPERIENCED SAMPLER

	Portion 1	Portion 2	Portion 3	Portion 4
Weight of sample, grams	722	856.5	1231	1508
Ash in dry coal	6.71	7.26	6.87	8.11
Sulphur	2.11	2.49	2.27	2.99
B.t.u.	14,690	14,558	14,688	14,428

27 It should be noted that this did not conform to the usual practice of taking two opposite quarters to be combined for the final sample of the coal. The portions taken were not even quarters, the last being nearly twice as large as the first. The results show that the final sample was not properly mixed to secure an even distribution of the coarse and fine particles through the pile and that it was carelessly quartered. Evidently some of the results are too high and others too low. By multiplying the B.t.u. value by the weight of each portion and determining the average for the entire final sample, it is found to be 14,571 B.t.u. The B.t.u. values are, therefore, above or below average, as follows:

	Portion 1	Portion 2	Portion 3	Portion 4
Variation	+119	−13	+117	−143

28 If such careless methods will give results within these limits one can surely depend upon careful preparation to give results within less than one-half of 1 per cent of the value of the coal. In support of this statement, the following facts are submitted.

29 The accuracy of this plan has been demonstrated in several instances when samples have been taken from the same lot of coal at the same time by a representative of the coal company and by a representative of the consumer. In one case more than 1000 tons of coal delivered from a barge were so sampled and analyzed and the representative of the consumer obtained results showing 8.75 per cent ash, while the representative of the coal company secured results showing 8.73 per cent ash in the coal.

30 On one occasion a coal consumer made a complaint to his

dealer about the coal which had been delivered. A representative of the dealer took a sample from a pile according to accepted methods. Later on a disinterested party was employed by the consumer to sample and test the same coal. The analysis of the first sample showed the ash in the dry coal to be 7.47 per cent. The second sample, when analyzed, was found to contain 7.49 per cent ash in the dry coal. The difference in the heating value of these two samples was 38 B.t.u. on the dry basis. These are remarkably close checks but many other instances show that samples properly taken may be expected to check within about one-third of 1 per cent of ash in the dry coal.

31 At another time coal from the same barge was sampled by both the consumer and the dealer with the following results:

	Sample Taken by Representative of Consumer	Sample Taken by Representative of Coal Dealer	Difference
Ash in dry coal	10.48	10.14	0.34
B.t.u. in dry coal	14,099	14,155	56

32 Another case shows that these methods will secure results which check reasonably well when samples are properly taken and that the results are not always as unfavorable to the coal dealer as they frequently assume. A coal dealer employed a disinterested party to sample coal from a barge as it was unloaded and a sample was taken by the consumer at his plant for one week. These samples were worked down and analyzed by separate laboratories with the following results:

	Sample No. 1 Taken by Representative of Coal Company	Sample No. 2 Taken by Consumer	Difference
Ash in dry coal	5.96	5.67	0.29
B.t.u. in dry coal	14,803	14,866	63

33 Such results can be obtained only when samples are taken and prepared for the laboratory by careful men who will follow instructions absolutely. It takes time to break down a sample properly and few laborers who are detailed to do this work realize the importance of the work, and a short or easy method is frequently used which may secure results far from right.

34 The fact that there may be small variations from the true heating value just as there may be in weight of the coal and that these variations are as fair to the buyer as to the seller, must be recognized. They will tend to offset each other during a period of a year. It is better to know within one per cent of the weight and of the heating value of coal than to have no information about it. It is possible to determine both with greater accuracy if only reasonable care is used.

35 Experienced fuel engineers and chemists are quite generally agreed that a sample of coal, taken by an approved method and analyzed by an experienced coal chemist, should show results which, when compared with the true values, are within the following limits:

Moisture	1.00 per cent of the coal as delivered
Ash + or −	0.50 per cent of the dry coal
Sulphur + or −	0.10 per cent of the dry coal
B.t.u. + or −	1.00 per cent of the dry coal

36 When samples are taken in a proper manner, the results will be sufficiently accurate for all commercial purposes and are within the limits which are found in the comparatively simple operation of determining the weights of the coal shipped. It is hardly worth while to adopt more costly methods of sampling coal in order to secure a greater accuracy, until the methods of weighing coal are improved and the accuracy of the weights guaranteed within less than 1 per cent.

THE SELECTION OF COAL

37 The problems of purchasing a supply of fuel for any given plant, so as to obtain a coal that is suitable for the equipment in use and one that will deliver the greatest amount of heat to the boiler for each dollar expended, is one which requires experience and an intimate knowledge of various kinds of equipment for burning coal, and also of the different characteristics of the coals available at reasonable freight rates.

38 The following information should be considered by the engineer in deciding on the best coal for a plant:

a Kind and size of boilers and furnaces
b Load conditions, average and maximum loads
c Draft available and how controlled

d Character of the coals offered or available
- (1) Moisture and its effect on weight of combustible matter delivered
- (2) Volatile matter and its relation to kind of furnace
- (3) Ash: its amount and its fusibility and tendency to clinker
- (4) Sulphur: the amount and how combined
- (5) Heating value in B.t.u.
- (6) Coking qualities of the coal

e Size of the coal
- (1) Relation of the size of coal to the equipment

SPECIFICATIONS FOR COAL

39 After it has been decided what kind of coals may be burned successfully in any given plant, it is important that the specifications be so drawn that it will be to the interest of the dealer to deliver the kind of coal which has been established as standard in his proposal and prevent the substitution of lower grades of coal which might be difficult to burn with good results. It is evident that a specification based on heating value alone will not do this and that there should be some clause making it possible to reject the coal, or to burn it and pay for it at a reduction in price greater than that due to B.t.u. only.

40 There has been a great deal said for and against the plan of purchasing coal on a guaranteed analysis and, as is often the case, both sides are right but they are really discussing different things.

41 A properly drawn specification protects the dealer who is prepared to furnish good coal in competition with dealers handling inferior coals at the same price. Where these specifications permit the coal contractor to state the analysis of his coal which on acceptance of the bid becomes the standard for the contract, there need be but little variation in the price if the dealer is familiar with the analysis of the coal offered, and if the standard is based on average values the premiums and penalties for the year should practically balance each other. Many dealers have bid on impossible analyses and then blamed the specification plan for their losses.

42 A properly drawn specification providing for premiums for better coal than that specified, encourages the coal operators to exercise greater care in mining and in picking the coal before shipping, and enables them to secure a return on the cost of such preparation. Most consumers have found that it is not profitable to pay freight on an unnecessary amount of slate and ash in the coal.

43 The important items in a specification are as follows:

a A statement of the amount and character of the coal desired.

b A statement regarding the conditions for delivery of coal.

c A statement regarding the disposition which will be made of the coal in case it is outside the limits specified.

d A statement regarding the corrections in price for variations in heating value, for variations in ash and for variations in sulphur, provided it is found advisable to limit the percentages of ash and sulphur in the coal to be delivered.

e A blank form on which the dealer may submit price and the kind and quality of coal which he proposes to furnish.

44 There are several forms which have been prepared along these lines which have proved satisfactory. It is necessary in almost every case to modify the specifications to fit the special conditions in the plant and the fuels which are available.

45 In the past many dealers not familiar with the quality of the coals have bid on contracts and guaranteed a quality of coal that was better than can be delivered from any mine in the United States. Naturally these analyses that had been useful as exhibits were found to be poor standards on which to base the guarantees of coal to be delivered. Many progressive dealers have recognized the reasonableness of the demand for a standard for quality of the coal to be delivered and they are selling coal on a basis which secures for them the average price they expect to get for the coal.

46 The importance of testing coal purchased under contract may be illustrated by two recent cases. In Case 1 the coal was guaranteed to be Georges Creek and in Case 2 to be New River (Table 3).

TABLE 3 DATA OF COAL PURCHASED UNDER CONTRACT

	Case 1		Case 2	
	Guaranteed Analysis as Delivered	Coal Delivered	Guaranteed Analysis as Delivered	Coal Delivered
Ash in dry coal	8.00	12.66	6.00	8.48
B.t.u. in dry coal	14,250	13,558	14,700	13,981

47 Neither of the parties in the above cases had made a practice of having the coal which was delivered at their plants, sampled and analyzed. In such cases the blame for paying a good price for a poor coal rests with the purchaser. The dealer probably knew as little about the quality as the man who paid for it.

48 The plan of purchasing coal on a specification based on a guaranteed analysis may or may not be a good one, depending on circumstances. It has proved satisfactory in nearly every case when the specifications were so drawn as to protect the buyer against substitution of other coals and at the same time was perfectly fair to both the buyer and to the seller. Such specifications actually protect the dealer against unfair competition as has been shown in many cases. This plan will not be satisfactory if the specification is carelessly drawn and the coal is selected on the basis of price without regard to its adaptability to the furnaces; nor will it prove satisfactory if the sampling is done by ignorant or careless men and the analysis made in poorly equipped laboratories by inexperienced chemists. Whether it will be advisable to purchase for a plant on this basis depends on the amount of coal used, the amount delivered at one time, the kinds of coal available and whether the purchaser and the dealers are qualified by a knowledge of the available coals to enter into a contract on this plan.

SUMMARY

49 There is a wide difference in the character of the various coals on the market and a considerable variation in the quality of the coals sold under the same general trade name. These differences make it difficult to secure the most enonomical coal for a given plant without an intimate knowledge of the coals and of the engineering problems connected with their combustion.

50 Careful investigations have shown that if coals are suited for use in the furnaces installed, they may be burned with practically the same efficiency and are of value in proportion to their heating values. Investigations have also shown that almost any fuel may be burned in suitably designed special furnaces so as to give results which are nearly proportional to their available heating value. In many cases it has been found advisable to change furnaces to utilize a low-grade fuel rather than to purchase an expensive coal for the existing equipment.

51 The management of any plant should know the quality of the coal in use and be able to locate the cause of variations in the boiler room economy. Poor results are not always chargeable to the coal. Operating conditions are frequently at fault. An analysis of a representative sample of coal which is suitable for the furnaces is a more

accurate measure of the value of the coal than the performance of the boilers.

52 This method of purchasing coal has already been adopted by many of the larger and most progressive consumers of coal. Its advantages are so clearly demonstrated to engineers thoroughly experienced in power house practice that few who are in a position to purchase large quantities of coal are willing to do so without a guarantee as to its quality. With information as to the coal bed, the district and the mine from which the coal will be furnished and the guaranteed analysis, an experienced engineer can select a coal for the plant which is both suitable and cheap when quality and price are considered.

53 A contract based on a guaranteed analysis provides for a definite procedure in settling for variations in the quality of the coal delivered and avoids the necessity of devoting much time to personal arguments and correspondence regarding poor coal. If both the consumer and the seller are familiar with the technical points involved in the sale of coal on a guaranteed analysis, it will prove a fair method by which the purchaser pays according to the value of the coal delivered to him and the dealer is reimbursed for any expense due to better preparation of the coal.

A REGENERATOR CYCLE FOR GAS ENGINES USING SUB-ADIABATIC EXPANSION

By A. J. Frith, Published in The Journal for July 1910

ABSTRACT OF PAPER

A new cycle of theoretically 100 per cent efficiency, caused by the expansion line being steeper than that due to free expansion, is presented in this paper, which shows that in the older regenerative cycles the loss of heat to water cooling overbalances the theoretical economy, a condition which is here avoided. How the brake efficiency, under practical conditions, may be derived from formulae, and a heat expenditure of 7000 B.t.u. be expected, with a compression pressure of only 125-lb. gage and a peak pressure of 275-lb. gage, are also described.

This means 50 per cent greater economy in fuel than is usual, say, with illuminating gas. A diagram showing the variations of regenerator efficiency with size, indicates that only practical conditions and temperatures are required to carry out the cycle. A design is shown in which no scavenging is required, no mixtures are made, and spontaneous ignition appears. While the danger of pre-ignition is avoided, the conditions for perfect combustion are coupled with light pressure and the need for ordinary good workmanship.

DISCUSSION

Sidney A. Reeve. Professor Frith's design for a regenerative four-cycle explosion-engine is a very interesting one and perhaps of real promise. It is impossible, however, to regard his explanation of its operation in so favorable a light; or, indeed, as correct at all. His theoretical argument attempts to establish a novel use of the regenerator, resulting in astonishingly high efficiency. The self-deceptive features of his argument cannot be pointed out without a brief summary of the place of the regenerator, an instrument unfamiliar to the present generation of power engineers, in heat-engine theory and practice.

All heat-engine argument necessarily starts with and is founded on the Carnot cycle. Its diagram, in the entropy-temperature field,

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the only true thermodynamic field, is the simple rectangle, like $ABCD$ of Fig. 10, made up of isothermals and adiabatics. This cycle, applied to steam engines, gives a very wide low diagram, like $ABCD$, Fig. 11. The objection to it is its limited height and efficiency. The secret of its great success, when approximated in the Rankine cycle $aBCD$ of the actual steam-engine, is its very great width, entropy and power per unit of volume.

The Carnot cycle applied to permanent gases gives a tall narrow diagram, like $ABCD$, Fig. 12. Although highly efficient, it has always been impracticable because of its narrow width or entropy and power per unit of volume, for both the adiabatic and the isothermal expansion of air, as along BC and CD, develop tremendous volumes per heat unit handled. The combination of these two processes within a single cycle, therefore, is too much for constructive costs.

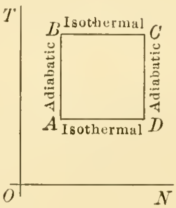


FIG. 10 DIAGRAM OF CARNOT CYCLE

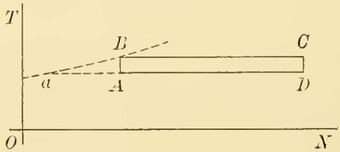


FIG. 11 CARNOT CYCLE APPLIED TO STEAM ENGINES

To avoid this trouble, and also that of Fig. 11, the regenerator was introduced. It was expected to retain high efficiencies, while avoiding excessive volumes, by eliminating adiabatic expansion. Yet Ericsson's regenerative hot-air engine of 1853, the furthest advance in that line, needed eight cylinders of 6 ft. stroke, four of them $11\frac{1}{2}$ ft. and four 14 ft. in diameter, in order to develop enough power to propel the ship Ericsson, 260 ft. long, at the speed of 7 mi. per hr. The regenerators for a much smaller engine comprised 456,000 ft. of wire to handle the heat from the combustion of $\frac{1}{4}$ ton of coal per hr.[1] What if such a machine as that did develop a horsepower from 11 oz. of coal per hr.! We could doubtless improve upon this showing today; but, even so, the promise of successful competition with non-regenerative engines is not brilliant.

A regenerative heat-engine develops, or approximates as best it may,

[1] Church. Life of John Ericsson, vol. 1, p. 188.

a diagram like *ABCD* of Fig. 13. Thermodynamically, its efficiency is the equivalent of the cycle *abcd*, or a perfect Carnot cycle, the regenerative actions *AB* and *CD* replacing the adiabatics *ab* and *cd*. For each bit of entropy received from the regenerator, as at *e*, in one cycle, having still to fall only the diminished temperature distance *ea* doing work, has already dropped usefully the distance *cf* in the preceding cycle. During the interim between cycles it has perched in the regenerator, or entropy-box, at the *e* level of temperature.

The principle of regeneration in heat-engines is to replace adiabatic temperature-change by regenerative temperature-change. If the adoption of regeneration does not eliminate adiabatic action the chief value of regeneration is gone, for we have then the burden of both processes and the full benefit of neither. Yet Professor Frith proposes to retain this combination as the soul of his new cycle.

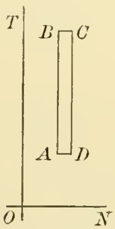


Fig. 12 Carnot Cycle Applied to Permanent Gases

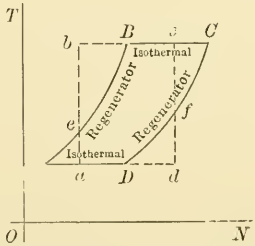


Fig. 13 Carnot Cycle Applied to Regenerative Heat-Engines

Theoretically the regenerative processes *AB* and *CD* of Fig. 13 might be carried out either at constant pressure or constant volume. In practice the conditions are neither the one nor the other; the gases are displaced through the regenerator by the pistons, thus undergoing alteration of volume; and at the same time the heat handled seldom exactly equals that needed to keep the pressure constant. Similarly, *BC* and *DA* may be carried out at either constant pressure or constant volume, as long as they are isothermals. In practice they are neither; but they never depart as far from isothermals as the corresponding lines of the sub-adiabatic cycle, *BC* and *DA* of Fig. 14.

In attempting to analyze Professor Frith's proposed cycle along the argument just outlined, difficulty arises. He starts out with the ordinary gas-engine cycle, which is like none of the above, but like *ABCD* of Fig. 14. Therein *AB* and *CD* are adiabatics and *BC* and *DA* are constant-volume isomorphics. He proposes to modify this by adding

regenerative action to the adiabatic CD, altering it to Cd, and to add the heat thus regained to the combustion-process BC.

This program presents a number of obstacles, viz.:

a The heat regained from regenerative action must be taken up at, or slightly below, the temperature of deposit. Therefore the heat regained along Cd below the B level (it is proposed to carry the point d to A) can be utilized only during compression; and adding heat during compression is against every canon of thermodynamics.

b Even the heat regained above the B level, if utilized along BC, can have no other result than to increase the peak at C, resulting in its being discharged by the increased jacket action necessary to keep the engine cool. In addition, the richness of mixture requisite for sufficient speed of combustion always supplies more heat than can

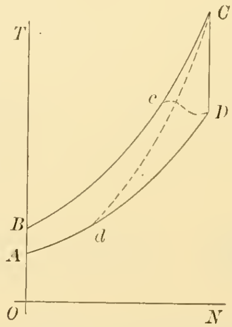


FIG. 14 ORDINARY GAS-ENGINE CYCLE

be utilized along BC. To offer the working-substance additional heat from the regenerator at this time of cycle is like carrying coals to Newcastle, or offering exhaust steam to a power house.

c The apparatus described by Professor Frith will never develop a regenerator curve like Cd, to trouble us with the above questions. Instead, it will act to drop the point C to c; that is, his regenerator space is the field of active combustion. Previous to combustion it will always be left comparatively cold by the two preceding strokes of admission and compression. Although possibly hot enough for ignition, it will be far below the temperature of explosion. Therefore, it will absorb heat greedily from the white-hot flame.

After this the flame expands somewhat in the little cylinder and then traverses the regenerator, completing its expansion in the large cylinder. In this the naturally vertical adiabatic from *c* will be distorted by the absorption of heat from the regenerator into some such path as *cD*, which will reach *D* only if the regeneration be perfect. This process *cD* is exactly the wall action of the existing gas-engine, so far as concerns the heat not carried on to the jacket water but reabsorbed during the working stroke. The importance of this action in engine-efficiency I have pointed out[1] where diagrams from actual engines quite similar to *ABcD* of Fig. 14 were presented. This wall action in existing engines frequently suffices to make the latter portion of the process *cD* virtually isothermal.

If Professor Frith's regenerator should be able to intensify this normal wall action by the presence of a vast regenerator surface, without too great incidental disadvantage, it might be of great value. The free fall of heat from *cC* to *cD* would be offset by a lessened need for jacket-water loss; but, in so far as his engine should do this, it would not be new, for I saw the general idea disclosed years ago, in papers I am not free to quote. His proposed arrangement, too, involves a regenerative interference with the processes of admission and compression which promises to be a heavy price to pay for the gain.

The form of Professor Frith's paper impresses one with the very great difficulty of thinking clearly through thermodynamic problems by means of pressure-volume notation, handled algebraically. No thermodynamic problem can be clearly understood until the essential factors, temperature and entropy, are separated from all others and portrayed clearly alone. All pressure-volume, temperature-volume, entropy-heat or other mongrel diagrams should be rigidly excluded, until the problem has been clearly stated and understood, if not solved, by entropy-temperature methods.

A. M. Levin. In view of all that has been said and proven with regard to the transformation of heat energy, it is somewhat of a surprise, at present, to have one's attention called to thermal cycles alleged to promise efficiencies ranking with the unit. Though the claims of Professor Frith with reference to his sub-adiabatic regenerative cycle may be apt to shake our faith temporarily in established axioms, they undoubtedly will not escape their due share of skepticism. Considering, however, that any hurried review of the formulae which are necessarily involved, may not generally lead to any absolute approval or disapproval of the claims set forth, I venture to

[1] Trans. Am. Soc. M. E., vol. 24, pp. 174–178, Figs. 46–51.

offer the following deductions, which it is believed will readily verify the facts of the matter.

Fig. 15 is practically the same as Professor Frith's Fig. 5 in Par. 19, though for the sake of clearness the lettering has been somewhat modified to suit the present purpose. The analytical expressions for the areas underneath the expansion lines CA and BA are

$$\text{Area } CAGF = \frac{P_c V_c}{n-1}\left[1 - \left(\frac{V_c}{V_a}\right)^{n-1}\right]$$

$$\text{Area } BAGF = \frac{P_b V_b}{k-1}\left[1 - \left(\frac{V_b}{V_a}\right)^{k-1}\right]$$

The area underneath the curve COD extended indefinitely is $\dfrac{P_c V_c}{k-1}$ and the area underneath the curve BA extended indefinitely is $\dfrac{P_b V_b}{k-1}$ while the area $CDXAC$ may be called $F^{\text{max.}}$ per cent of the area between the lines CD and BA extended indefinitely.

In the latter part of Par. 21 we have the formula:

$$\text{Eff.}^{\text{max.}} = \frac{\dfrac{P_c V_c}{n-1}\left[1 - \left(\dfrac{V_c}{V_a}\right)^{n-1}\right] - \dfrac{P_b V_b}{k - -1}\left[1 - \left(\dfrac{V_b}{V_a}\right)^{k-1}\right]}{(1 - F^{\text{max.}})\left(\dfrac{P_c V_c}{k-1} - \dfrac{P_b V_b}{k-1}\right)}$$

Thus

$$\text{Eff.}^{\text{max.}} = \frac{\text{Area } CAGF - \text{Area } BAGF}{\text{Area } CDXAB - \text{Area } CDXAC}$$

$$\text{Eff.}^{\text{max.}} = \frac{\text{Area } CAB}{\text{Area } CAB} = 1, \text{ or 100 per cent}$$

That is, the ratio of the work realized less the energy regenerated to the total energy supplied by the combustion less the energy rejected during the expansion equals the unit.

The Eff.$^{\text{max.}}$ expressed by the above equation is, however, not the thermal efficiency of the cycle unless the total heat rejected during the expansion, the area $CDXAC$, is absorbed by the regenerator and returned to the working charge during the compression, from A to B, without expenditure of energy. Evidently this cannot be accomplished because only that part of the rejected heat above the lower

temperature limit can be regenerated. Assuming the charge to be admitted and heated by the regenerator under atmospheric pressure, the lower temperature limit will be that corresponding to the atmospheric pressure. The energy regenerated will be the area $CODAC$, and if there is no heat loss in the regenerator the area $CODAC$ = area BAI.

The process and the thermal efficiency ratio of the cycle are more clearly shown in the entropy-temperature diagram[1] Fig. 16. Starting from the point I we supply heat to the working substance by means of compression and regeneration, following the line IB; from B to C heat is supplied by combustion; from C to A heat is discharged to the regenerator, while the expansion follows the line CA; and from A to I

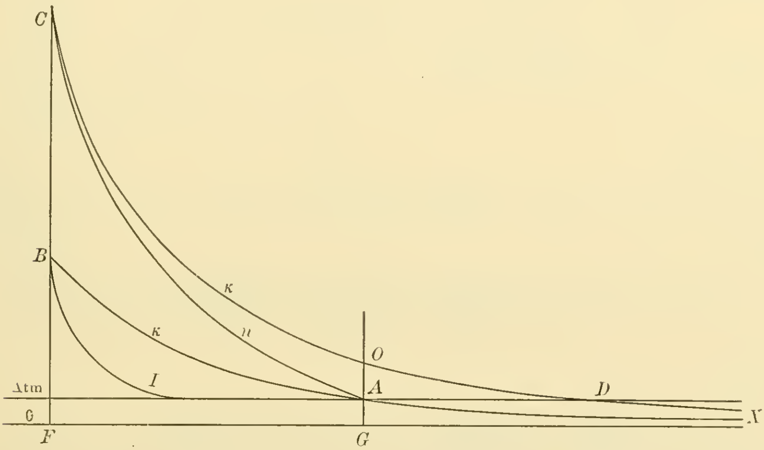


FIG. 15 SUB-ADIABATIC REGENERATIVE CYCLE (FIG. 5)

heat is discharged at a constant pressure. Hence, the net work realized is represented by the area $IBCA$. The heat discharged to the regenerator, above a temperature corresponding to the atmospheric pressure, is the area CDA, and the heat regenerated is the area IBA (Fig. 16).

Assuming the regenerator efficiency to be 100 per cent, then the area $CDA = IBA$ and the net work realized may be represented by the area $BCDA$ enclosed between the adiabatic compression line AB, the adiabatic expansion line CD, the constant-volume line BC, and the constant-pressure line AD. The heat supplied by combus-

[1] A. M. Levin. The Modern Gas Engine and the Gas Producer.

tion is the area $BCKL$, and consequently the thermal efficiency of the cycle is

$$E = \frac{\text{Area } BCDA}{\text{Area } BCKL}$$

The heat supplied during the combustion B to C is

$$Q_1 = C_v (T_c - T_b)$$

(T_b and T_c representing absolute temperatures at the points B and C) and the heat rejected in the exhaust is

$$Q_2 = C_p (T_d - T_a)$$

Hence

$$E = \frac{C_v (T_c - T_b) - C_p (T_d - T_a)}{C_v (T_c - T_b)} = 1 - \frac{C_p}{C_v} \times \frac{T_d}{T_c} \times \frac{1 - \frac{T_a}{T_d}}{1 - \frac{T_b}{T_c}} \quad [1]$$

We have

$$\frac{T_d}{T_c} = \left(\frac{P_d}{P_c}\right)^{\frac{k-1}{k}}; \dots\dots\dots\dots [2]$$

Also

$$\frac{V_c}{V_d} = \left(\frac{P_d}{P_c}\right)^{\frac{1}{k}}, \text{ or } \frac{V_a\, V_c}{V_a\, V_d} = \left(\frac{P_d}{P_c}\right)^{\frac{1}{k}}$$

Hence

$$\frac{V_a}{V_d} = \frac{V_a}{V_c}\left(\frac{P_d}{P_c}\right)^{\frac{1}{k}}; \quad \text{but as } \frac{V_a}{V_d} = \frac{T_a}{T_d}$$

therefore

$$\frac{T_a}{T_d} = \frac{V_a}{V_c}\left(\frac{P_d}{P_c}\right)^{\frac{1}{k}} \dots\dots\dots\dots [3]$$

and

$$\left(\frac{T_a}{T_d}\right)^k = \left(\frac{V_a}{V_c}\right)^k \frac{P_d}{P_c}$$

We have further

$$T_b = \left(\frac{V_a}{V_c}\right)^{k-1} T_a$$

and

$$T_c = \left(\frac{V_d}{V_c}\right)^{k-1} T_d; \; V_c \text{ being } = V_b$$

Thence, by division

$$\frac{T_b}{T_c} = \left(\frac{V_a}{V_d}\right)^{k-1}\frac{T_a}{T_d}, \text{ or } \frac{T_b}{T_c} = \left(\frac{V_a}{V_d}\right)^{k}; \ \frac{T_a}{T_d} \text{ being } = \frac{V_a}{V_d}$$

and

$$\frac{T_b}{T_c} = \left(\frac{V_a}{V_c}\right)^{k}\frac{P_d}{P_c} \dots\dots\dots\dots\dots\dots\dots [4]$$

Substituting [2], [3] and [4] in [1] we get

$$E = 1 - \frac{C_p}{C_v}\left(\frac{P_d}{P_c}\right)^{\frac{k-1}{k}} \times \frac{1 - r\left(\frac{P_d}{P_c}\right)^{\frac{1}{k}}}{1 - r^k\frac{P_d}{P_c}}$$

when the compression ratio $\frac{V_a}{V_c} = r$.

The above is the same thermal efficiency as that of the Atkinson cycle.

The thermal efficiency of the common Otto cycle when the heat is rejected according to the constant-volume line OA (Fig. 16) is

$$E_o = 1 - \frac{1}{r^{k-1}}$$

To make a comparison between the efficiencies E and E_o possible it will be necessary to assume a certain initial pressure from which the sub-adiabatic expansion starts. We may assume: P_c = 450 lb. per sq. in. and P_d = 15 lb. per sq. in., from which $\frac{P_d}{P_c} = \frac{1}{30}$; the expansion ratio, in both cases the same, $r = 6$; $k = 1.4$; $\frac{k-1}{k} = 0.286$; and $\frac{1}{k} = 0.714$. For the sub-adiabatic regenerative cycle we get

$$E = 1 - 1.4\left(\frac{1}{30}\right)^{0.286} \times \frac{1 - \left(\frac{1}{30}\right)^{0.714} \times 6}{1 - \frac{1}{30} \times 6^{1.4}} = 0.58$$

The efficiency of the Otto cycle becomes for $r = 6$

$$E_o = 1 - \frac{1}{6^{0.4}} = 0.51$$

Assuming, thus, a regenerator efficiency of 100 per cent, then E will be approximately 14 per cent higher than the efficiency of the Otto cycle.

By cooling the expanding charge to a point M below the constant pressure line and rejecting heat along the constant-temperature line MA, a somewhat greater efficiency could be obtained. This would require the regenerator to be cooled by the incoming charge

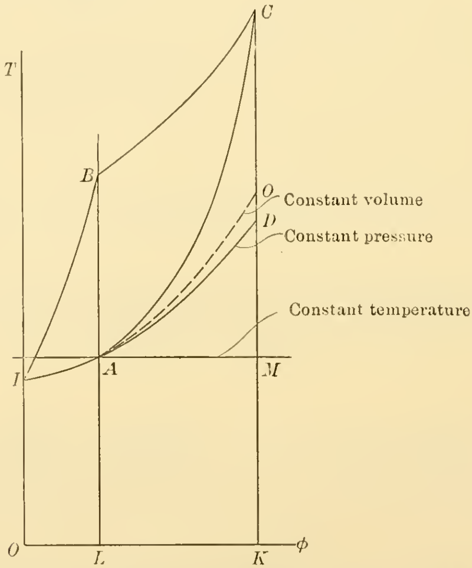


FIG. 16 ENTROPY-TEMPERATURE DIAGRAM

to the low point M and is probably not contemplated in the present cycle.

The Otto cycle is in the entropy-temperature diagram represented by the area $ABCO$, and it will be evident that the temperature range for the two cycles is nearly the same. The required displacement volume is also the same for both and, consequently, practically the same cooling surface will be involved in both cases, excepting that the sub-adiabatic cycle, requiring two cylinders, would include one additional cylinder head.

As the sub-adiabatic regenerative cycle requires a regenerator, an

apparatus whose efficiency cannot, practically, be equal to the unit, it may be proper to debit its thermal efficiency with the loss sustained in the regenerator. The ratio of the heat regenerated to the heat supplied is

$$\frac{\text{Area } CODAC}{\text{Area } CDXAB} = R$$

$$R = \frac{\dfrac{P_c V_c}{k-1}\left[1 - \left(\dfrac{P_d}{P_c}\right)^{\frac{k-1}{k}}\right] - \dfrac{P_c V_c}{n-1}\left[1 - \left(\dfrac{V_c}{V_a}\right)^{n-1}\right] - (V_d - V_a)P_d}{\dfrac{P_c V_c}{k-1} - \dfrac{P_b V_c}{k-1}}$$

Dividing by

$$\frac{P_c V_c}{k-1}$$

and substituting

$$\frac{V_d}{V_c} = \left(\frac{P_c}{P_d}\right)^{\frac{1}{k}}$$

and

$$\frac{P_b}{P_c} = \left(\frac{V_a}{V_c}\right)^k \times \frac{P_d}{P_c}$$

we obtain

$$R = \frac{1 - \left(\dfrac{P_d}{P_c}\right)^{\frac{k-1}{k}} - \dfrac{k-1}{n-1}\left[1 - \left(\dfrac{V_c}{V_a}\right)^{n-1}\right] - (k-1)\dfrac{P_d}{P_c}\left[\left(\dfrac{P_c}{P_d}\right)^{\frac{1}{k}} - \dfrac{V_a}{V_c}\right]}{1 - \left(\dfrac{V_a}{V_c}\right)^k \dfrac{P_d}{P_c}}$$

If, as before, $\dfrac{P_c}{P_d} = \dfrac{450}{15} = 30$ and $\dfrac{V_a}{V_c} = r = 6$

then

$$n = \frac{\log \dfrac{P_c}{P_d}}{\log \dfrac{V_a}{V_c}} = \frac{\log 30}{\log 6} = 1.9$$

and the percentage heat regenerated becomes

$$R = \frac{1 - \left(\dfrac{1}{30}\right)^{0.286} - \dfrac{0.4}{0.9}\left[1 - \left(\dfrac{1}{6}\right)^{0.9}\right] - 0.4\,\dfrac{1}{30}\left(30^{0.714} - 6\right)}{1 - 6^{1.4} \times \dfrac{1}{30}} = 0.33$$

Hence, 25 per cent of the heat supplied is directly transformed into work and 33 per cent is regenerated. If we now assume a minimum loss in the regenerator of 20 per cent, then the total thermal efficiency of the cycle becomes $E = 0.25 + 0.8 \times 0.33 = 0.514$, which is practically the efficiency of the Otto cycle.

In view of this and of the indirectness of its process, it may appear doubtful that the sub-adiabatic regenerative cycle can be of great practical usefulness, though as a thermal cycle it is probably new and of interest.

R. C. H. Heck. Consider the general case of the Frith scheme, as outlined in Fig. 4, and here represented, in both the pressure-volume

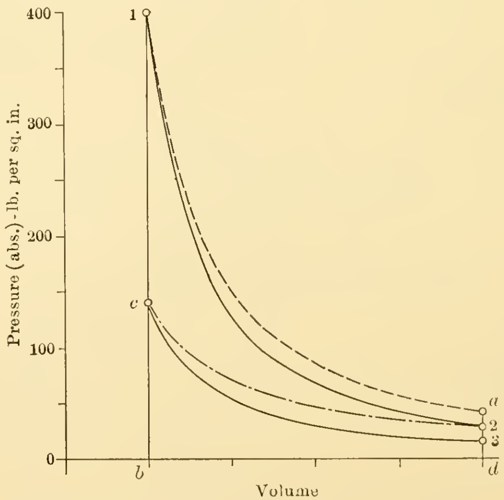


Fig. 17 The Frith Cycle—General Case

and temperature-entropy planes, by Figs. 17 and 18. These are laid out from the governing proportions given in the example in Par. 27, namely, $p_1 = 400$, $p_c = 140$, $p_3 = 14.57$ (there 15), $k = 1.406$, $V_1 = 1$, $V_2 = 5$. Fig. 17 is not related to any chosen quantity of gas, but Fig. 18 is drawn as for one pound of air. Both diagrams are in true proportion.

Outline *c1a3* represents the ideal Otto cycle, with adiabatic expansion. To get the sub-adiabatic expansion, curve *12*, it is assumed that heat can be abstracted by a regenerator in such a controlled and regular fashion as to produce a curve of the form $pv^n = C$, and that this heat can be perfectly restored to the medium during the heat-receiving

operation *c1*. Disregard for the present the isothermal *c2*, which fixes the lower limit of possible regeneration, and also the line *1xy* in Fig. 18 which illustrates a concluding remark.

It will be well to get an expression for the efficiency of this cycle which shall be wholly in terms of the dimensions of the diagram, without involving the awkward regenerative factor F. In some parts paralleling the deduction in the paper, the operation is as follows. The output of the cycle is

$$U = \frac{P_1V_1}{k-1}\frac{k-1}{n-1}\left[1-\left(\frac{V_1}{V_2}\right)^{n-1}\right] - \frac{P_cV_1}{k-1}\left[1-\left(\frac{V_1}{V_2}\right)^{k-1}\right] \ldots [1]$$

The total heat taken up by the charge during the constant-volume heating *c1*, area *c1db* in Fig. 18, is

$$H = \frac{P_1V_1}{k-1} - \frac{P_cV_1}{k-1} \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

Of this the regenerator supplies the amount *21dc*, which it has abstracted from the preceding cycle, leaving to the source the requirement of supplying *23bc* plus *c123;* that is, the new heat to be added equals the heat rejected during operation *23* plus the net output of work. For the heat rejected we have

$$R = \frac{P_2V_2}{k-1} - \frac{P_3V_3}{k-1}$$

$$= \frac{P_1V_1}{k-1}\left(\frac{V_1}{V_2}\right)^{n-1} - \frac{P_cV_1}{k-1}\left(\frac{V_1}{V_2}\right)^{k-1} \ldots\ldots\ldots\ldots [3]$$

The heat supplied is, therefore,

$$Q = R + U = \frac{P_1V_1}{k-1}\frac{k-1}{n-1}\left[1-\left(1-\frac{n-1}{k-1}\right)\left(\frac{V_1}{V_2}\right)^{n-1}\right] - \frac{P_cV_1}{k-1} \ldots [4]$$

Dividing U by Q to get efficiency E, then dividing through by $\frac{P_1V_1}{k-1}$, we have

$$E = \frac{\frac{k-1}{n-1}\left[1-\left(\frac{V_2}{V_1}\right)^{n-1}\right] - \frac{P_c}{P_1}\left[1-\left(\frac{V_1}{V_2}\right)^{k-1}\right]}{\frac{k-1}{n-1}\left[1-\left(1-\frac{n-1}{k-1}\right)\left(\frac{V_1}{V_2}\right)^{n-1}\right] - \frac{P_c}{P_1}} \ldots\ldots [5]$$

This expression may look complicated, but it is better and clearer than equation [5] in Par. 26.

The fallacy in the paper, which leads to unit efficiency, is involved in the assumption that regenerative action can be carried to the lower limit of temperature, at point *3* in Fig. 17. Heat may be abstracted,

perhaps readily enough, but it cannot possibly be returned to the medium if stored at a temperature lower than t_c, at which heat reception begins. In other words, if any part of the regenerator is cooled below t_c, it must act as a receiver, not as a source of heat, whether during the latter part of operation *3c* (destroying adiabatic compression) or during *c1*. Here the second law of thermodynamics shows its remorseless sway.

As already intimated, the isothermal *c2* fixes at *2* the lower limit of terminal pressure for true regeneration and determines the condition of maximum efficiency for the cycle in its ideal form. To get the value of n in this particular case, we have first the general relation

$$\frac{P_2V_2}{P_1V_1}\left(\frac{V_2}{V_1}\right)^{n-1} = 1 \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

then the special relation $P_2V_2 = P_cV_1$; therefore,

$$\left(\frac{V_2}{V_1}\right)^{n-1} = \frac{P_1}{P_c}$$

and

$$n - 1 = \frac{\log P_1 - \log P_c}{\log V_1 - \log V_2} \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

Figs. 17 and 18 are drawn for this limiting condition of maximum efficiency, with the leading dimensions given in the first paragraph of this discussion. The value of n is 1.651 (as against 2.058 for Frith's "maximum" for Fig. 5). The efficiency, by use of equation [5], is

$$E = \frac{\frac{0.406}{0.651}\left(1-0.3507\right) - \frac{140}{400}\left(1 - 0.5203\right)}{\frac{0.406}{0.651}\left[1 - \left(1-\frac{0.651}{0.406}\right)\times 0.3507\right] - \frac{140}{400}}$$

$$= \frac{0.4049 - 0.1678}{0.7609 - 0.3500} = \frac{0.2371}{0.4109} = 0.577$$

The use of $n = 2.058$ makes $E = 1$, fulfilling mathematical requirements, but divorced from physical fact.

That all the heat received by the regenerator down to t_c can be returned to the charge after the beginning of operation *c1* is a purely ideal (and unattainable) assumption. Actually, there must be a considerable "head" of temperature, both into and out of the regenerator, or the latter must be cooler (in some part) than the coolest gas from which it is to take heat, and hotter than the coolest gas to

which it is to give heat. The curve *1x*, sketched in on Fig 18, represents what is probably a fair and liberal concession as to the possibilities of the whole scheme. The regeneration of heat *1xyd* would be helpful, but would hardly revolutionize the gas engine.

All this discussion has been concerned with purely ideal conditions. To form even a preliminary judgment as to how well the actual regenerator can perform the function assigned to it, one would have to make a far closer and more definite study of the movements of the charge than is even suggested in the paper. To all reasonable appearance, with the proportions indicated by Figs. 8 and 9, it looks as though the action of the small amount of regenerator surface would be

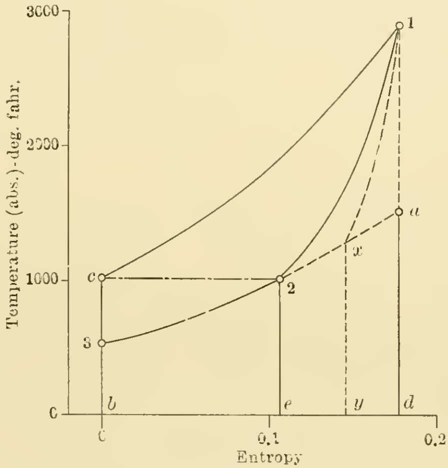


FIG. 18 TEMPERATURE-ENTROPY DIAGRAM FROM FIG. 4

completely overshadowed by that of the very much larger amount of cylinder-wall surface, the latter being backed by a relatively tremendous mass of metal in which there is a steep temperature gradient toward the water-cooled outer surface. Any conclusion based purely on reasoning, whether from theory or from empirical knowledge along analogous lines, must be fully confirmed by actual test before it can be accepted as established.

W. T. MAGRUDER asked Professor Frith if this engine had ever been built. Upon receiving a negative reply, he said that experience led him to think that it would not give the diagrams assumed. He understood that the assumption was made that the heat is all generated along the ignition line, whereas such had not been the case

in gas engines as he had experimented with them. When the temperature-volume diagram is taken, as obtained with a Le Chatelier pyrometer, it will probably be found that the temperature at the middle of the stroke is higher than at the beginning, and possibly still higher at the point of release. Temperatures as high as 2400 deg. fahr. have been experimentally obtained at the end of the expansion. This would make the expansion curve not an adiabatic, but one more nearly isothermal, and possibly one of increasing temperature. He had come to the same conclusion from the use of the combustion sight-hole indicator,[1] consisting of a plate-glass window in the end of the cylinder of the gas engine. Looking through it, one can see the ignition take place and the gases continue to burn in each cycle. For these reasons he could not accept the assumption so common in textbooks, namely, that all heat is generated instantaneously, and that the expansion is adiabatic. Such assumptions may answer for the ideal case, but are not in accordance with practice as he had seen it.

Chas. Whiting Baker. The author says that the cylinders are connected by a free passage through a regenerator, and he also says there is no clearance in the cylinder. Apparently, then, the volume of the regenerator would have the same effect as an equal volume of cylinder clearance. The drawings (Figs. 8 and 9), show a very small regenerator and a good-sized cylinder. Regenerators, as the author has remarked, are very little known at the present day; but a good many years ago I witnessed one of the old hot-air engines working, which was equipped with a regenerator. Many inventors thirty or forty years ago worked on the design of hot-air engines, of which a regenerator was one of the integral parts. They endeavored to make these regenerators as small as possible, but at best the volume of the regenerator was necessarily several times that of the cylinder. They used to make the regenerators of wire gauze, so as to get the largest regenerative effect in the smallest space; but even then the regenerator was a bulky thing in comparison with the cylinder. In actual work, although the thermal efficiency of the hot-air engine was beyond anything that the steam engine attains, the engine was a commercial failure because the regenerator was extremely short lived.

The Author. If the limitations (Par. 24) and the explanation (Par. 25) had been considered, much of this discussion would have been

[1] Engineering News, May 15, 1902, p. 385.

avoided and I might not have been called upon to defend a position I do not occupy. I do not consider that the essential point in this theory has been even mentioned in the discussion. There is an apparent flow of heat in the diagram from a lower to a higher level. If it were so it would be fatal, but it is not true. There is a law that water cannot flow up hill, but no one would quote it against the operation of the hydraulic ram which seems to violate it, because the intervening mechanism is too well known. But suppose it were not so apparent; can not one see how it would be used? The point involved in the present discussion is analogous to this example.

There is apparently a flow of heat from the lower to the higher level and no intervening mechanism or condition can be used in the mathematical demonstration or tolerated in an ideal card. It is not apparent, but it is there and is discussed in Par. 25. All the discussion turns on this point, so we will take Professor Heck's discussion as typical. He calls attention to the necessity of the lower temperature of the regenerator being above the higher temperature of compression. This is admitted in Par. 24. He then deduces the lower temperature of the cycle *from the card* and uses this temperature to show that regenerative action is impossible. Regenerators, however, are governed by the *actual temperatures* with which they are in contact, and I will show that the cycle temperatures *from the card* are not the temperatures at the regenerator surfaces and that using them for such a purpose leads to absurd results. Hence, as the cycle temperature taken *from the card* is the basis of this argument, and in fact of all the arguments, all deductions thereafter and the results obtained from them are also absurd.

That further misunderstanding may be avoided, I refer to Fig. 19, in which let *ABCD* represent a vessel containing a pound of air. In a partition dividing it there is a hole (h) so that both ends are in free communication. At one end a steam pipe passes through the chamber with a valve as shown. A gage on the vessel gives the pressure of the air. The steam is at 850 deg. abs., the air in one end of the vessel is at 600 deg. abs. and at the pipe end it is 1000 deg. abs. Let the pressure be 40 lb., the volume 50 per cent and the other conditions such that from $\frac{PV}{T} = C$, $T = 800$ deg. This is the temperature of the air in the system calculated from pressure and volume. It is a *card temperature,* the average temperature of the air. But it is not the *actual temperature* at either end of the vessel. Now the second law of ther-

modynamics, as used in this discussion, states that as heat cannot flow from a lower to a higher level, if the valve were opened the 850 deg. steam would give up heat to the air which has a *card temperature* of 800 deg. But since it is really in an atmosphere of 1000 deg., such a statement is absurd, for it is evident that the reverse is true and that the steam would extract heat from the system, while apparently by *card temperatures* heat would flow from the lower level of 800 deg. to the higher level of 850 deg. This is due to the fact that there are two different temperatures actually existing in the vessel. The wider this difference of actual temperatures the greater the absurdity of using *card temperatures* as the basis of the calculation.

Of course the problem would not be changed if a regenerator replaced the steam pipe in contact with the hotter end of the system. As Professor Heck admitted that the deductions in the paper were mathematically correct and as the above illustration demonstrates

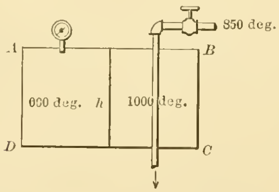


FIG. 19 VESSEL CONTAINING ONE LB. OF AIR

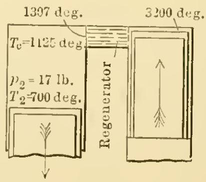


FIG. 20 ACTUAL TEMPERATURES OF FRITH CYCLE

that the flow of heat from a lower to a higher level (*card temperatures*) is not a physical impossibility if a difference of temperatures in the system be wide enough, to that extent he upholds my contention.

To clear up the point raised by Professor Magruder I made a calculation similar to that in Par. 21, in which heat, such as might be supplied by after burning, is added. It offsets in part the heat extracted by the regenerator and increases the heat added by combustion. Incidentally it may keep the temperature in the small cylinder constant, replacing heat abstracted in that cylinder by the work during expansion. This calculation also gives 100 per cent efficiency, but calls for a higher maximum efficiency of regeneration, 85 per cent for the case in Par. 27 (see Fig. 20). Where $T_1 = 3200$ deg. and T_c of compression = 1125 deg., it figures out that the temperature in the small cylinder is always 3200 deg. and is the *actual* temperature in contact with the regenerator. The lower temperature of the regenerator being 1307 deg. *actual*, all controlling temperatures are above the

1125 deg. of compression and the regenerative action may continue to the end of the card, where the pressure for the whole system figures about 17 lb. and the *card temperature* of the cycle is only 700 deg. This regenerative action at *actual temperatures* is possible where the *card temperatures* make it look like a heresy. The efficiency in this case, figured from a calculation like that in Par. 32, is 98 per cent, very close to unity but higher than I would have expected at this limit of action.

I regret exceedingly that the discussion was confined to this 100 per cent efficiency. After all it is only mathematical and the ideal conditions involved are totally unattainable, while for the actual conditions of practice this action of a wide difference of actual temperatures can be maintained, even if it be questionable whether it holds good to the mathematical limit. It does give an apparent upward flow of heat and as the heat is actually transferred at low *card temperatures* it has the same effect as the thermal impossibility, though it is only a trick of construction, the intervening mechanism, analagous to that which is well known and effective in hydraulic rams.

Mr. Baker's remarks in reference to regenerators are, I believe, strictly true, but the inference is not correct. By referring to Fig. 6 it will be seen that the 90 per cent efficiency of the old regenerators gives a length seven times as long as the 50 per cent regenerators proposed, and as the gases will also be transferred under high pressure as against the atmospheric pressures used in the past, the port areas will be smaller by about 1 to 8. Hence the bulk may be $7 \times 8 = 56$ times smaller for this system.

Referring to Par. 37*c*, it will be found that at ignition, when destructive combustion was predicted by Professor Reeves to upset regenerative action, there is nothing but air, that is no flame in the regenerator. Hence the basis of this argument seems to be, in part, imaginary and is certainly exaggerated. I may add that an expression that agrees with actual tests is opposed to the conclusions of Professor Reeves.

It appears to me that the whole subject of thermodynamics is founded on the necessary assumption of an even temperature at any given point of a cycle, that its laws are subservient to this assumption, and in a case like this, where there is purposely a wide departure from the assumption, that possibly the broad limiting deductions may not apply. It is for this reason that my mathematical discussions are expressed in intrinsic heat, not temperatures, and that a physical relation which we can reasonably estimate was used

to check the results. As Professor Reeves points out, thermodynamics is founded on the Carnot cycle and for that very reason with the intolerance of pure mathematics it may not recognize any ultimate solution or cycle differing from this basis. It is believed that to this departure from the underlying assumption and to the use of a cycle that has no isothermal loss we may ascribe for ideal conditions the promise of 100 per cent efficiency. The general effect of this relation will give us a large increase of economy with practical conditions.

Referring to Professor Reeve's temperature-entropy diagrams, it is evident that in the Carnot cycle the function of the isothermal lines is to increase and decrease the entropy and that it is the heat withdrawn by the lower isothermal that prevents the cycle from approaching unity. As Professor Reeves aptly states, in the older regenerative cycles regeneration replaces the adiabatics, leaving the lower isother-

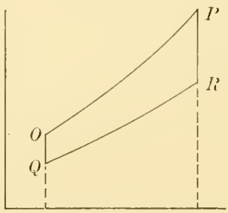


Fig. 21 Cycle of Adiabatic and Constant-Volume Lines

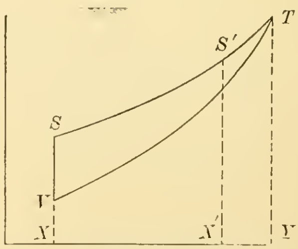


Fig. 22 Cycle of Fig. 21 Modified

mal to represent as before a positive loss. If we attempt to replace by regeneration the isothermal instead of the adiabatics we would, if it be practicable, cut out the very line that prevents perfection. Imagine a diagram like Fig. 21, with adiabatics and lines representing the addition of heat at constant volume, regeneration taking place after adiabatic cooling. This cycle seems to be impossible, because the card temperatures during QR are lower than those of OP. But if we combine the adiabatic PR and the regenerative withdrawal of entropy QR into one line TV, Fig. 22, its average card temperature is apparently lower than ST, but not its actual temperatures of heat transfer, all of which figure to be higher than S because the adiabatic cooling takes place after the regeneration, though it cannot be shown directly in this form of diagram. But, as I have tried to demonstrate, by the use of a wide difference of actual temperatures, regeneration from TV to ST is possible, then the area $VTYX$ may

equal $XSS'X'$ (heat regenerated) and $X'S'TY$ (heat of combustion) may equal the work done, STV. Hence the efficiency may be 100 per cent for ideal unattainable conditions. A complete temperature-entropy diagram at maximum efficiency for the example in Par. 27 proves every item of our contention, but, with its necessary explanation, it is too long to be here considered.

MODERN SHOE MANUFACTURE

By M. B. Kaven and J. B. Hadaway, Published in The Journai for December 1910

ABSTRACT OF PAPER

This paper treats of the ancient methods of covering the feet, the old-time shoe shop in which each workman was taught to make the entire shoe; the making of the hand-sewed shoe; the advent of the sole-sewing machines, the direct means of revolutionizing the shoe industry; and subsequent inventions substituted for hand work which finally led to the building of the modern shoe factory.

A description is given of such a factory provided with all the modern improvements for the health, comfort and safety of the employees, equipped with the latest type of shoe machinery; and of the principal operations in the making of the shoe, from the cutting of the leather until it is ready for the shipper, with some account of each machine used in these operations. A thorough description is also given of the Goodyear welt sewing machine from which the welt shoe derives its name.

APPENDIX No. 1

DATA FOR FOUR-STORY GOODYEAR SHOE FACTORY

Factory space	300 ft. long by 50 ft. wide. Four floors
Floor space	60,000 sq. ft.
Capacity of factory	3600 pairs men's Goodyear shoes per day Approximate space per pair 16 sq. ft.
Machines in factory	Driven throughout by $1\frac{1}{2}$ h.p.–15 h.p. three-phase 60-cycle motors—550 volts Power to be supplied by a local electric light company

FACTORY PLAN

Fourth floor	Cutting room and stitching room
Third floor	Making room
Second floor	Finishing room, treeing and dressing room, packing and shipping room and general offices
First floor	Sole leather and stock fitting room

Plans are shown in Figs. 7, 8, 9 and 10.

POWER REQUIRED TO DRIVE MACHINES

	H.p. Motors	Total H.p.
Fourth floor	1–$1\frac{1}{2}$, 1–10	26.5
Third floor	1–15, 1–10, 2–$7\frac{1}{2}$, 2–5	50.0
Second floor	1–10, 2–3	16.0
First floor	1–10, 1–5, 1–3	18.0
Total h.p. for machines		110.5
Estimated power for 2 exhausters		30.0
Estimated power for elevator		10.0
Total h.p. required		150.0

Approximate List of Employees Required by the Factory

Cutting room, mostly men	82
Stitching room, mostly women	160
Making room, mostly men	155
Finishing room, mostly men	40
Treeing and packing room, men, boys and girls	47
Sole leather room, mostly men	54
Total	538

NUMBER, KIND AND CAPACITY OF MACHINES USED

Cutting Room—Fourth Floor

Approximately 82 employees are required

No.	Machine	Capacity per machine doz. pairs per day
18	Clicking machines (all parts of upper)	16
	(tops)	38
12	Skiving machines	26
2	Perforating machines	30
2	Tip punching machines	200
4	Upper stamping machines	75
41	Hand cutters (outsides)	6
	(tops)	15

Stitching room—Fourth Floor

One hundred and sixty-four stitching tables for machines and work benches with ten 1½-h.p. motors for drive. Approximately 160 employees are required in this room. Number of machines and operators could be added to as per quality of work exacted.

No.	Machine	Capacity per machine doz. pairs per day
3	Closers (vamps)	110
3	Box toe stitchers	110
5	Tongue stitchers	60
5	Closers (tops)	75
4	Tip stitchers (4 needle)	60
8	Stayers (2 needle)	30
4	Stayers (button fronts)	73
16	Lining stitchers (closers)	25
2	Zigzag stitchers	110
3	Back stayers	60
4	Top facers (back stayers)	80
4	Plain stitchers (labels)	75
4	Eyelet row stitchers	75
15	Under trimmers	20
5	Back stayers (outside)	40
4	Buttonhole machines (24 holes per pair)	5000 holes
2	Buttonhole finishing machines	...
2	Hook setters	165
2	Eyeletting machines	175
3	Barrers (toe linings)	85
25	Vampers (2 needle cylinder)	12
5	Vampers (1 needle cylinder)	7
2	Boston folders	150
3	Barring-up machines	125
2	Button fasteners	100
5	Power cementers	...

Making Room—Third Floor

No.	Machine		Capacity per machine doz. pairs per day
8	Pulling-over machines	Four lasting rinks	40
8	Assembling machines		40
8	Hand method lasters (side lasting)		40
16	No. 5 lasters (toe and heel lasting)		20
1	Tack pulling machine		300
2	Tack pullers and resetters		150
8	Welters		40
1	Power welt groover and beveler		...
1	Inseam trimmer		...
2	Shank welt skivers		150
2	Welt beaters and slashers		150
1	Channel cementer		300
3	Twin sole layers		100
3	Loose nailers		150
6	Universal rounders and channelers		50
2	Channel openers		150
16	Outsole lockstitch machines		20
1	Channel cementer		300
2	Channel layers		150
2	Stitch separators		100
2	Welt indentors and burnishers		150
2	Heel seat rough rounders		150
3	Automatic sole levelers		100
4	Heelers		75
3	Sluggers		100
3	Heel trimmers		100
2	Heel breasters		150
3	Heel scourers		125
15	Edge trimmers		20
7	Twin edge setters		45
2	Welt indentors and burnishers		150
1	Toe tip scourer		...

Finishing Room—Second Floor

Approximately 87 employees are required

No.	Machine	Capacity per machine doz. pairs per day
3	Heel breast scourers	125
5	Heel scourers	75
6	Buffing machines	50
3	Double head pneumatic buffing machines	100
3	72-in. finishing shafts (staining)	100
5	Heel finishers	65
4	72-in. finishing shafts (faking)	100

Finishing Room—Second Floor (Con.)

No.	Machine	Capacity per Machine doz. pairs per day
1	Loose nailing machine (reinforcing)	300
2	Power stampers	150
1	72-in. finishing shaft (cleaning)	...

TREEING AND PACKING

16	Twin treeing machines	20
1	Vamp creasing machine (f. p.)	300
1	Power marking machine (box marker)	300

Sole Leather Room—First Floor

No.	Machine	Capacity per machine doz. pairs per day
3	9-ft. sole cutting machines (outsoles)	110
6	4-ft. sole cutting machines (innersoles and top lifts)	125
1	Evening and grading machine	400
1	30-in. rolling machine	350
2	$7\frac{1}{2}$-in. splitting machines	150
2	Sole rounding machines	150
2	Feather edge and shank reducers	150
2	Tap skiving and rand splitting machines	200
1	Twin sole molding machine	350
2	Tap and sole rounding machines	150
1	Heel compressing machine	350
6	Power heel building machines	50

GEM INNERSOLES

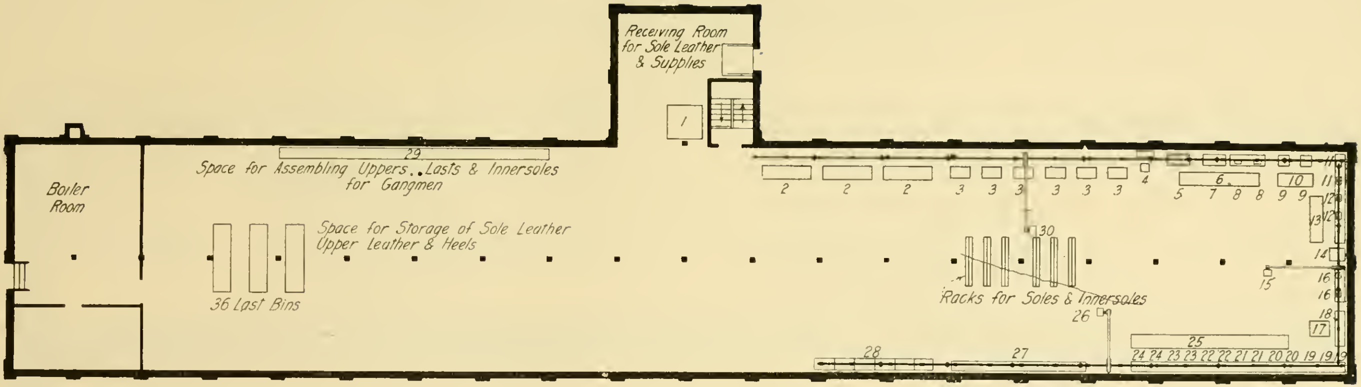
3	Universal channeling machines	125
2	Lip-turning machines	150
2	Rotary cementing machines	150
2	Insole channeling machines	150
2	Insole stitchers	...
2	Insole reinforcers	...

To this number should be added the office force, which would vary from 10, if the product is sold to the jobbing trade, to 30, if to the retail trade.

This factory is planned for a shipment each day, allowing for an occasional delay, but does not provide for an indefinite storage of the manufactured product.

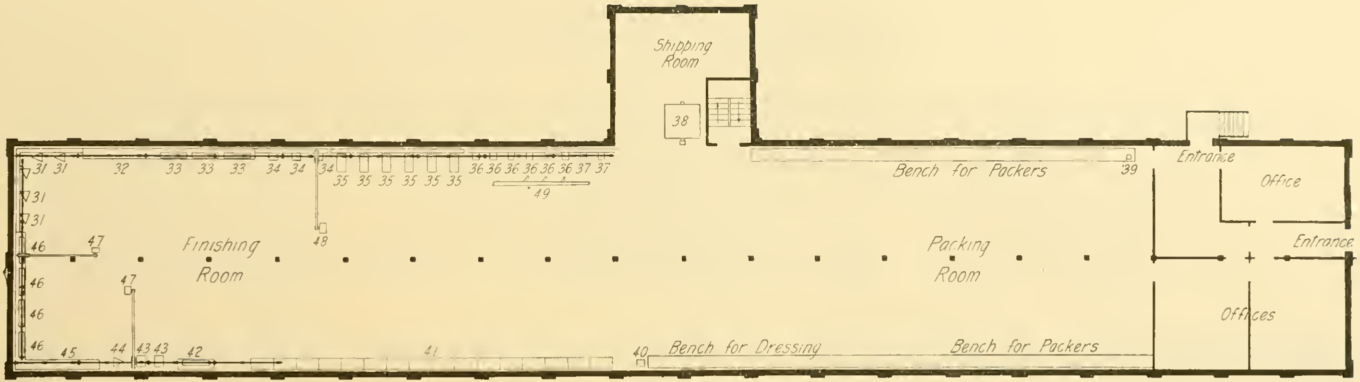
The floor plans (Figs. 7, 8, 9 and 10) represent a four-story factory building each with 15-ft. bays and 2 windows to a bay. The window area should be as large as possible.

The plans show the machines used in their proper order. The outline of the base of the machine is shown, with the necessary benches as required by different machines. The necessary shafting for driving the machines, with the proper size of motor for each drive is also shown. The position of the operator is also shown.



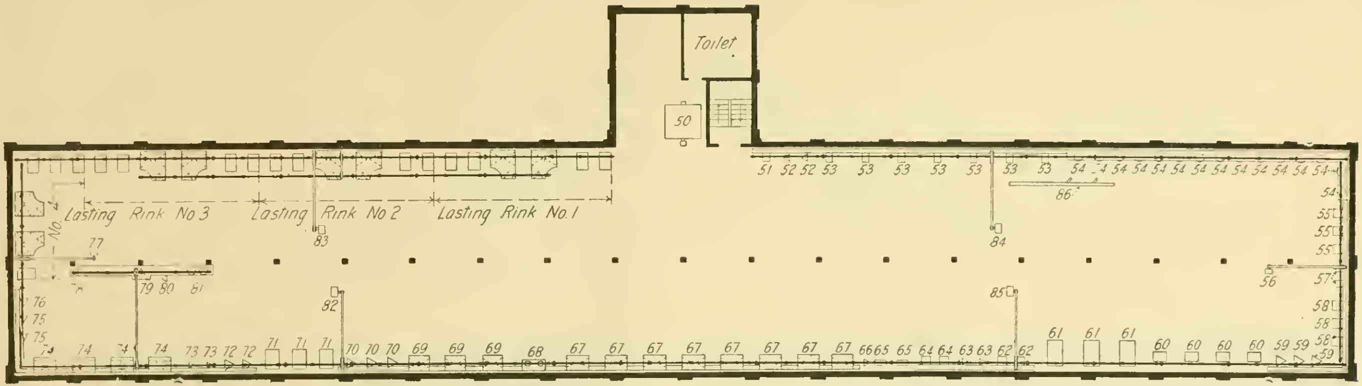
1 Elevator, 8 ft. × 8 ft.
2 Three sole cutters (outsoles and innersoles), 9 ft.
3 Six sole cutters (tops and lifts), 4 ft.
4 Evener and grader
5 Wetting-up tank
6 Work table
7 Rolling machine, 30 in.
8 Two splitting machines, 7½ in.
9 Two sole rounders
10 Rack for patterns
11 Two feather edge and shank reducing machines
12 Two tap skiver or rand splitting machines
13 Work table, 3 ft. × 10 ft.
14 Twin sole molder.
15 5-h.p. motor, 1730 r.p.m.
16 Two tap and sole rounders
17 Heel compressor
18 Heel sorter
19 Three universal channelers
20 Two lip turners
21 Two rotary cementers
22 Two insole channelers
23 Two insole stitchers
24 Two insole reinforcers
25 Stock table, 3 ft. × 35 ft.
26 3-h.p. motor, 1730 r.p.m.
27 Sorting bench
28 Six heel-building machines
29 Bench for assembling lasts, innersoles and uppers for gang men

FIG. 7 FOUR-STORY GOODYEAR SHOE FACTORY
FIRST FLOOR—SOLE LEATHER ROOM



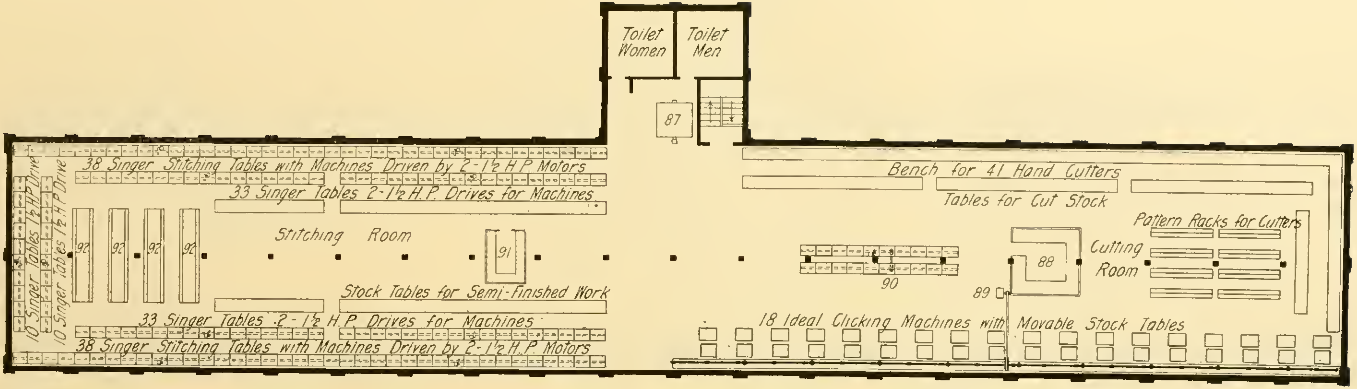
31 Five heel finishers
32 Bench for three blockers
33 Three finishing shafts (staining), 72 in.
34 Three double-head pneumatic buffers
35 Six buffing machines
36 Six heel scourers
37 Three heel breast scourers
38 Elevator, 8 ft. × 8 ft.
39 Power marking machine
40 Vamp creasing machine (f.p.)
41 Sixteen twin shoe treeing machines
42 Finishing shaft (cleaning), 72 in.
43 Two power stampers
44 Loose nailer for reinforcing
45 Bench for three last pullers
46 Four finishing shafts (faking), 72 in.
47 Two 3-h.p. motors, 1730 r.p.m.
48 10-h.p. motor, 1740 r.p.m.
49 Six buffing machines

FIG. 8 FOUR-STORY GOODYEAR SHOE FACTORY
SECOND FLOOR—FINISHING, TREEING AND PACKING ROOM



50 Elevator, 8 ft. × 8 ft.
51 Toe tip scourer
52 Two welt indentors and burnishers
53 Seven twin edge setters
54 Fifteen edge trimmers (machines set in bench)
55 Three heel scourers
56 5-h.p. motor, 1730 r.p.m.
57 Two heel breasters
58 Three heel trimmers
59 Three sluggers
60 Four heeling machines
61 Three automatic sole levelers
62 Two heel seat rough rounders
63 Two welt indentors and burnishers
64 Two stitch separators
65 Two channel layers
66 One channel cementer
67 Sixteen outsole lockstitchers (8 on each drive, benched in as shown)
68 Two channel openers
69 Six universal rounders and channelers
70 Three loose nailers
71 Three twin sole layers
72 Two welt beaters and slashers
73 Two shank welt skivers
74 Eight welters (benched in as shown)
75 Two tack pullers and resetters
76 Tack puller
77 5-h.p. motor, 1730 r.p.m.
78 Power welt groover and beveler
79 Inseam trimmer
80 Channel cementer
81 Bottom filling with heaters
82 10-h.p. motor, 1740 r.p.m.
83 7½-h.p. motor, 1740 r.p.m.

FIG. 9 FOUR-STORY GOODYEAR SHOE FACTORY
THIRD FLOOR—MAKING ROOM



87 Elevator, 8 ft. × 8 ft.; 10-h.p. motor drive
88 Stock room for upper leather
89 10-h.p. motor, 1740 r.p.m.
90 Twenty Singer stitching tables, 1½-h.p., motor drive (12 Amazeen skivers; 2 perforating machines; 2 tip punching machines; 4 upper stamping machines)
91 Supply room for cut stock, etc.
92 Four assembling racks for finished stock

Fig. 10 Four-Story Goodyear Shoe Factory
Fourth Floor—Cutting and Stitching Room

DISCUSSION

E. J. Prindle. The art of shoe manufacture should be of interest to mechanical engineers, since the paper states that the making of a Goodyear welted shoe involves the use of 60 different machines. The making of a shoe is a peculiarly difficult and interesting process. The same machines are required to turn out shoes which vary quite widely in sizes and shapes and there is no straight line and nothing to measure from as a base in the view of the ordinary mechanical engineer. Leather is a difficult material to work because it varies considerably in thickness and in stretch, making it difficult to cut out a piece of proper size for a definite part of the shoe. Many of the operations depend upon the success of the preceding ones. This fact, together with the uncertainty of the material and the difficult shape, makes it exceedingly difficult to turn out a good shoe.

The machines involve very interesting mechanical movements and a surprising variety of adjustments to provide for lasts of definite shape of toe, different length and width. There has been an amount of ingenuity displayed in that direction greater than in any other branch of engineering.

Each factory makes its shoes of no standard shape back of the instep, so that there is little uniformity in shoes of different manufacturers. At present, however, there is a strong tendency to make the heel and everything back of the instep of a standard shape in all factories. Another modern tendency is to develop machinery to take the place of the operative now required to hold the shoe up to the machine and to turn it around so that the edge is continually presented.

R. H. Long.[1] This paper describes well the way a welted shoe is made at the present time and has been made in the shoe factories during the past twelve years.

There has been little progress in shoe manufacturing since 1899, and the advancement since that time has been largely in the division of work; the operations being so divided that skilled labor is used only on the important parts and unskilled labor to large extent.

[1] Shoe Manufacturer, South Farmington, Mass.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

There has also been much improvement in patterns and in shapes of lasts. The lack of progress so far as machinery is concerned, is owing to the fact that nearly all the shoe manufacturers of the country are controlled by contracts with the United Shoe Machinery Company that prevent the use of competing machines. At the present time the American shoe has not the pronounced leadership in the world that it had ten years ago.

The Authors. The criticism made by Mr. Long regarding the United Shoe Machinery Company may be refuted by the fact that the company produced during the past year at least 20 new machines in which there are many patentable features of merit and which will result in a saving to manufacturers. The company spends many hundreds of thousands of dollars annually in perfecting new and improved machinery for making shoes and at the present time an exceptionally large number of experimental orders pertaining to improvements and devices are being worked upon. The company endeavors at all times to give shoe manufacturers the benefit of all improvements in shoe machinery made by it, and great advancement is being made at the present time in the production of such machinery. One new invention alone gives promise of saving shoe manufacturers at least two cents on each pair of shoes made.

THE SHOCKLESS JARRING MACHINE

By Wilfred Lewis, Published in The Journal for May 1910

ABSTRACT OF PAPER

The development of machine molding has been limited in the past to machine of comparatively small capacities, but the author believes that the greatest development and the largest savings are to be anticipated in large work quite beyond the capacities of machines hitherto considered practicable. The paper deals with the key to this development, the shockless jarring machine, a new type of jarring machine in which the shock heretofore transmitted to the ground is absorbed as effective work by the machine itself. This machine saves substantially all of the ramming time, and, in combination with others, saves pattern-drawing and finishing time and opens the way to economies of startling magnitude in the foundry. Other labor-saving appliances may be employed still further to reduce the molding time on any given piece of work.

The principles governing the design of a jarring machine include solidity of construction and freedom from vibration in the jarring table, avoidance of shock on foundation from impact, convenience of control, accessibility to all working parts, and economy of power. Solidity of construction is the most important and economy of power the least important consideration. The jarring process is quick and effective, but seldom economical in the consumption of power. Efficiency depends chiefly upon the weight of anvil used, and to some extent upon the length of stroke, the expansive use of air, the clearance, and the character of the sand. The shockless anvil is more efficient than the same anvil cushioned on a wooden crib, and when equal in weight to the loaded table it is twice as effective.

The shockless jarring machine requires no foundation beyond that necessary to sustain the static load, and for this reason it is well adapted for use on the upper floors of buildings, where many foundries are now being located.

DISCUSSION

E. H. Mumford. This admirably clear exposition of a most ingenious machine contains a theory of the action of jolt-ramming machines and some assumptions as to other machines which are disputable.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

In his broad statement of the minute or less required to jolt-ram a mold, and of the effect of anvil recoil, and that the longer the stroke the greater the efficiency, the author ignores the time, varying with the depth of the mold, required for the density of the sand below gradually to reach the top, and treats the compacting of sand by jolt-ramming machines as occurring uniformly and simultaneously throughout the mass.

I refer to the process and not the result, for, although in the finished mold there is a comparatively slight difference in density at top and bottom, a much greater difference exists during the early stages of the ramming and has to be taken account of in anvil and drop conditions. In October 1909 I called the attention of the Philadelphia Foundrymen's Association to the fact that a zone of proper mold density rises gradually from the approximately horizontal joint and pattern surfaces until it nearly reaches the top. Practically as well as theoretically it never does reach the actual top in the time in which the rest of the mold becomes hard enough; and the extreme upper layer must be hand-rammed unless excess sand is used and struck off. In this case, the unrammed upper layer will be in this excess. Were this not true, the many experiments which have been made in ramming molds by dropping sand in cartridges would have borne fruit.

It is stated in Par. 17 that "the longer the stroke the greater the efficiency." If this were correct then a single long stroke of 30 x $2\frac{1}{2}$ in. = 6 ft. 3 in., should ram a mold better than 30 strokes of $2\frac{1}{2}$ in. each. The fact that such a long and, according to the author, efficient stroke, does not ram a mold except in its lower regions, although the author says it should, shows that he thinks of jolt ramming as affecting all parts of the mold simultaneously although the lower layers may be squeezed a little harder by the superincumbent sand. A fall of many times this height, however, would not compact the upper regions of a relatively deep mold, for the simple reason that the lower regions have not been set by previous blows to a rigidity able to transmit the anvil effect. In other words, only the lowest sand gets the effect of a quick stop or high rate of change in velocity, while the uppermost sand lands so gently on the partly rammed sand below as to confute the hypothesis that ramming proceeds uniformly at all depths.

The author gives in Par. 21, as the reason for this behavior of the sand, that "the greater the change in velocity at the moment of impact the greater the ramming effect." Now, in all the upper regions of the mold, where the sand has considerable depth, the rate

of change in velocity at the instant of impact is practically nothing, nor does it become considerable until the sand below has been brought to a density sufficient to transmit effectively the impact on the anvil to the sand above.

For this reason I have stated that the jolt-ramming of sand is a progressive process in which the first impact rams the sand next the rigid horizontal planes to the maximum density possible for the machine, matchboard and patterns used. The next impact affects the sand immediately above *through the medium of the sand already rammed* and so on to the top of the mold in gradually diminishing density. In other words, the inequality in density of the sand at bottom and top of the mold, practically infinite at the first impact, because then the sand at the top is practically wholly unrammed, diminishes as the zone of hard sand rises toward the top. This has nothing to do with the comparative densities of rammed and unrammed sand, but has to do with rammed densities. Unrammed sand has relatively none. This, I think, must be evident. So far as the effect of jolt-ramming is concerned, unrammed sand is zero in density and sand rammed at all is infinitely dense in comparison.

This analysis is the only one which can follow the law stated by the author and just quoted, in which he uses the expression, "the change of velocity at the instant of impact." I think he will agree that no change in velocity of a body *at the instant* of impact is finitely possible, and that what was intended was "the rate of change of velocity at the instant of impact."

In the abridged history given of machine molding, mention should be made of the stripping plate, without which the art cannot be considered complete. Vibrators, though used on molding machines since 1893 for much machine molding, have never displaced the stripping plate. At the outset also the author assumes that the foundrymen have only "hitherto attempted to ram sand by the jarring process." This is a false assumption, for jolt-ramming of sand has been perfectly done for twenty years and numbers of machines good for 15 tons on the table have been in successful use for several years.

In reference to the designation in Par. 18 of the tables of other machines as "flimsy," other designers seek to avoid the large percentage of unnecessary weight and destructive shock involved in making the table carry the heavy stiffening which it needs only at the moment of impact and their machines receives and supports it on an ample surface at this time.

The author defines jolt-ramming machines as "capable of ramming any mold large or small in a minute or less time." This would lead to a mistaken idea that the size, or rather the depth, of a mold is immaterial in a machine of given capacity. One of our 16-in. machines which rams a 10-in. barred green sand cope with 20 blows in 10 seconds requires a minute and a half to ram an ingot mold core 6 ft. deep with 190 blows.

Reference is made in Par. 10 to pattern-drawing machines. Such machines as Mr. Lewis advocates require that the patterns should be attached to the machine, which is not the case with the simple jolt-ramming machines. Pattern-drawing machines as adjuncts to jolt-ramming machines do not save time, for they exact separate transportation of flasks and sand between the machine and molding floor, otherwise unnecessary. A recent description of one of these combination machines, costing over $2000, gave its output with four men as 50 truck wheel centers in ten hours. A plain jolt machine costing $900 has made 40 wheel centers in the same time with three men for the past four years with no pattern-drawing machine at all.

Money should not be spent for heavy stationary power machines to roll molds and draw patterns when a crane will pick up any mold by flask trunnions, on which it has practically rolled itself by the time it is set down where it is wanted. All then needed is a pattern guide, and a simple modification of the time-honored "steady-pin" or flask pin gives that in ninety-nine cases out of a hundred.

In Par. 12 the author gives all the work except the crane work on 16 molds 45 in. x 60 in. x 30 in. (such a mold might weigh 5500 lb.) as done in eight hours, and thus overlooks the great question of lifting and carrying in connection with the jolt-ramming of large molds. There are 64 lifts and carries to be made on this job. So it can be judged in how far from the eight hours named it is possible to make and finish 16 molds of this size with the help necessary to perform only the operations described in the schedule.

I think the author exaggerates the damage by shock or jarring of the foundry floor by jolt-ramming machines. Of course a great deal depends upon the nature of the work near the machine. In congested localities in cities, where heavy machinery such as steam hammers is objectionable to the neighborhood, a machine such as the author's finds a unique fitness. Heavy hanging green sand cores should not be placed near jolt-ramming operations, especially on swampy ground, but abundant testimony is to be had that the simpler form of machine is no such Aetna-shaking Pluto as claimed.

We have put in service a 32-in. plain machine, which with 100 lb. air service is ramming half molds weighing 40,000 lb., and the question of shock in the foundry is ridiculed by the management. Were anvils of other designers' machines as badly proportioned as reported there might be some excuse for the strictures made; but they are not.

It is assumed in the paper that the "weight of the anvil is generally limited to the weight of the loaded table," and the author develops from this assumption that the ordinary jolt-ramming machine has only 25 per cent efficiency as compared with one having an anvil of infinite weight, or bedded on rock. Fortunately for the art, anvils in use are quite commonly three times and sometimes seven times the weight of the maximum loaded table, which means that anvils are from six to at least ten times the weight of average loaded tables. Only one builder has followed the bad practice of placing a timber crib on top of the concrete. What this means follows:

Ratio Anvil To Loaded Tables	Efficiency of Machine	Remarks
Anvil equals loaded table	25 per cent	Assumption by author
Anvil twice loaded table	44 per cent	Minimum practice under maximum load
Anvil three times loaded table	55 per cent	Usual practice under maximum load
Anvil six times loaded table	73 per cent	Occasional practice under maximum load
Anvil seven times loaded table	77 per cent	Usual practice under average load
Anvil ten times loaded table	81 per cent	Occasional practice under average load

So it seems that the author claims that current jolt-ramming practice wastes two to three times as much energy as in fact it does.

The shockless jarring machine referred to in Par. 31 as having 50 per cent efficiency as compared with a machine having an infinite anvil, has an anvil of comparatively trivial mass, but doing the work of an anvil of infinite mass by stopping the falling table dead at impact.

This compares well with the 25 per cent derived in the paper for other machines, but does not look so well beside the 55 to 81 per cent with which they should be credited.

Now let me raise the question of mechanism. In the first place it is to be remembered that a machine which is mechanically fit for machine-shop or even smith-shop use may be a failure in the foundry.

Dry sharp sand is omnipresent. It might be thought that in a closed pit under a machine the flying, cutting, erosive dust would not prevail. But the pit is not closed. There is inevitably a fissure around the table through which during its operation, a steady shower of sand falls in a thin sheet to the bottom of the pit, a distance of fully 12 ft. in the machine described, in the presence of a blast surging up and down through the floor openings produced by the pulsations of the table, and a hurricane of dust if the exhaust is open to the pit as shown in the illustrations.

What will be said of the upturned, open, working joint of this subterranean cylinder in the "shockless" machine? And in the bottom of this cup, in water and intruding sand, under a reciprocating mass of 32 tons (57 tons and more, loaded) are 22 springs. Springs like men are temperamental. We all know how some lazy springs in a group will shift their load to abler partners and let their side sag.

The author has provided a "drip cock" to let the water out of the bottom of the spring box and cylinder guiding 65,000 lb., but what will be done with the sand? Is exhaust pressure in this cylinder supposed to keep the sand out? Experience with lubricated or wet plunger fits exposed to sand is that air gets out while sand gets in.

Still another foundry condition militates against the design of this machine. Not one load in a hundred placed by a crane on the table of a jolt-ramming machine is balanced over the plunger. Jolt-ramming plungers of all machines are suffering from eccentric loading.

The centers of gravity of sand molds are rarely in the vertical center lines of the flasks; and it is practically impossible to balance them by the eye on the machine tables. In a machine of such magnitude, the moment due to the jamming and wearing of the plunger may amount to many thousand foot-pounds. The lopping over of plungers in jolt-ramming machines due to unbalanced loading and wear is bad enough with one plunger; with two we would have the wear of one added to that of the other.

The author seems to have overlooked the fact that it is easy to secure balanced loading of these tables by a boss in the center of the table which serves to locate molds centrally. Corresponding wooden sockets on the match boards are, by a simple balancing on rollers, located vertically under the centers of gravity of the molds.

In order that the ramming impact in any jolt-ramming machine may be according to mechanical law, the center of gravity of the

loaded table and the center of gravity of the anvil must be in the same vertical line. It is easily practicable to keep jolt-ramming impacts central, and I believe it vital to any so-called "shockless" machines in which, as in this Tabor machine and as in steam hammers, the heavy deflecting shocks of eccentric impact are delivered to the mechanism instead of to *terra firma*.

Other designers of jolt-ramming machines find an absolutely reliable plunger compression a far more satisfactory agent for controlling table stability than springs of which the author shows 22 in the base and one in the top, while practically all the energy absorbed in this *air* spring is immediately utilized for the next blow.

A. E. Outerbridge. The chief objection to jarring machines has been ground waves due to shock. Granted that this trouble may now be eliminated, without loss of ramming power and proper flow of sand, by means of the floating anvil, there is apparently almost no limit to the future development of the molding machine. Even today, quite large castings are being made successfully on jarring machines, that a few years ago would have been considered beyond the capacity of any molding machine.

In the foundry of Wm. Sellers & Co., Inc., a jarring machine made by the Tabor Mfg. Co. negotiated flasks 80 in. x 70 in. x 40 in. deep in the drag and 16 in. deep in the cope, containing 120 cu. ft. of sand. The live heads for several large lathes have been made on this machine in this flask, the weight of the sand and the flask being 16,880 lb. and the weight of the casting about 9000 lb. Machine uprights have also been made in flasks 140 in. x 50 in. x 38 in. deep in the drag and 10 in. deep in the cope. This flask contains 129 cu. ft. of sand; the sand and flask together weigh 20,640 lb. These castings being of comparatively thin section, weigh about 4500 lb. each.

Apart from the lower cost of molding these large castings on the jarring machine there is a more uniform weight of duplicate castings and a more uniform distribution of the sand. The absence of "spongy spots" and "hard spots," inseparable from hand ramming, tend to insure good castings.

The chief, if not the only objection, to the operation of this machine in the foundry is the "earthquake," tending to cause sand to drop in contiguous molds in the floor, and in order to overcome this arrangements are now being made to adapt the shockless principle to the jarring machine already installed. When this has been accom-

plished it is believed that green sand molds with large overhanging portions can be safely made in the floor alongside of the shockless jarring machine.

THE AUTHOR. In reply to the discussion which has been given on my paper, I am grateful for the appreciation expressed and for any well-founded criticisms, whether favorable or otherwise, which may lead to further improvement, but I object to unwarrantable assumptions as the basis for conclusions which do not apply to the subject in hand.

I do not propose to argue whether the adjective "flimsy" applies more pointedly to a light thin wafer of cast iron which can be easily sprung or peened out of shape, than to a deep beam securely braced in all directions, because foundrymen generally have ideas of their own and no lack of adjectives to give them force. I deny, however, that my jarring table is loaded down with excessive weight because of its enormous strength and stiffnesss. Metal well distributed is used to good advantage, and here again no argument is needed.

It has been said that I treat the compacting of sand by jolt-ramming machines as occurring uniformly and simultaneously throughout the mass, whereas in the second paragraph of my paper, I say, referring to this method of ramming, "The sand is rammed as it should be, densest at the surface of the pattern and of decreasing density above, thus favoring the escape of gases when the mold is poured." I never had any other idea about it, and never met anyone who pretended to think that jar-ramming formed a crust on top of a mold while the sand beneath was nice and soft. There is nothing in my paper to indicate in any way that my understanding of the process is at all different from the common understanding of it as set forth by my critic. Nor does the acceptance of this understanding affect my contention that the longer the stroke the greater the efficiency. The ramming effect referred to in my paper is the kinetic energy given out by a change in velocity due to impact, and utilized more or less in compacting the sand. I do not contend that the longer the stroke the better the mold nor that one stroke of 75 in. is better than 30 strokes of 2.5 in. I recognize distinctly the limitations in length of stroke imposed by the practical considerations of strength and stiffness in patterns, flasks and the machine itself, and the advantage of repeated blows, but I dispute the possibility of ramming as hard on a short stroke as on a long one, notwithstanding the contention made to the contrary. Further than this,

the fact as I have stated it has been demonstrated by experiment and I am quite prepared to prove that in jar-ramming, the longer the stroke the greater the efficiency. On a shockless jarring machine with variable stroke, I have rammed a deep mold by giving it several hundred blows 1 in. long until the compacting of the sand appeared to have reached its limit. Then by increasing the length of stroke from 1 in. to 4 in., I have seen the very next blow reduce the depth of sand nearly 2 in. and succeeding blows naturally produced less and less movement as the ultimate density of the sand for the greater drop was approached. I am very confident, therefore, that there is an ultimate density for every length of stroke, and when this truth is realized, as it must be by anyone who takes the trouble to investigate, there can be no question as to the truth of my contention that the longer the stroke the greater the efficiency of a jarring machine. Take for instance, the mold above referred to, which has been rammed to its ultimate density by 1-in. strokes. A hundred more strokes of that length would have no perceptible effect, but one stroke of 4 in. would have a very substantial effect. After the ultimate density corresponding to the drop has been reached, all of the power expended is wasted, and nearly all the power used is wasted as this ultimate density is approached. Economy of power clearly points to the use of the longest stroke practicable, while on the other hand, the wear and tear on the machine, flasks and patterns suggest moderation and the adoption of a safe limit within which the stroke can be varied to meet the exigencies of any given case. It is better, I believe, not to begin jarring with a very long stroke, on account of the air confined in the sand, which may cut a channel for itself and blow if the stroke is too long, but after the sand has been well settled, I am very sure the stroke can be lengthened with great economy in power and generally with very good results.

It should also be observed that continued jarring after the mold has reached the ultimate density due to the stroke not only wastes power but spoils the mold, for as soon as the sand ceases to pack it begins to break up. The success of the process, therefore, depends a good deal upon knowing when to stop as well as upon the character of flasks, sand and patterns and the knowledge gained by actual experience in any given case.

The progressive nature of jar-ramming from the bottom up is, I believe, self-evident, but the density of sand when unrammed on the floor or rammed up in different parts of a mold is naturally proportional to its weight per unit of volume under these different con-

ditions, and if unrammed sand had no density it could not have any weight and would be lighter even than air. Zero density has been attributed to the ether which is supposed to fill all space, but never before to sand. If it be true as stated in the Iron Age (July 1909) that the density of sand is increased 25 to 30 per cent by ramming, it can hardly be true as stated now by the same authority that the difference in density of the sand at top and bottom of the mold is practically infinite at the first impact.

As to the change in velocity of the table at the instant of impact, I mean, of course, the change in velocity during that very minute fraction of a second while the pressure of impact exceeds the static load. I do not mean the *rate* of change in velocity at the instant of impact, because that rate does not hold throughout the duration of contact, and it has very little to do with the final result.

I am said to assume at the very outset of my paper that foundrymen have only "hitherto attempted to ram sand by the jarring process," in answer to which I would refer to the third paragraph, which begins "Jarring machines have been in practical use for many years without attracting much attention. The records of the patent office go back to 1869," etc., making further comment on this criticism superfluous. Nor does it refute my estimate of the time needed to ram any mold on a jarring machine to say that some machines require a minute and a half to do what the shockless machine certainly could do in a minute or less time.

As to the damage done by shock in the foundry floor, a good deal of evidence has been presented in discussions of the subject at various meetings, Mr. Outerbridge has confirmed it in his discussion and many others have had the same experience. Where the shock of steam hammers has to be endured, I do not think it would be worth while to put in a shockless jarring machine, but the choice rests with the user, and in addition to the evidence for the need of a shockless jarring machine already adduced, let me quote a paragraph from a letter received from abroad: "We are employing in our foundry a jarring machine with 48 in. x 60 in. table, on which we make molds weighing with sand and flask from 1500 to 2000 Kos. but our neighbors are complaining of the shocks which are transmitted to the ground and are even damaging our molds when we place the cores."

In regard to the weight of anvil being generally limited to that of the loaded table, I would say that this conclusion was reached from a number of observations, and confirmed indirectly by the

same authority who now disputes it. I am glad to be assured, however, that my estimate is too low, because the greater the weight of anvil or the more the money buried under ground by competitors, the better for the shockless machine, whose uprising anvil is always more efficient than an anvil of double its weight mounted on a wooden crib.

I know there is some prejudice against the use of springs, founded chiefly upon ignorance of the duty they should be made to perform. I have seen a great many springs which failed to act as intended and sometimes this has been due to the use of wrought iron or brass instead of high carbon spring steel properly tempered, but when good material is employed, I have seldom known a spring to fail except from bad design, and good steel springs within certain well defined limits, I believe to be as reliable as any other piece of mechanism. The railroads are the largest comsumers of spring steel. They specify the working stresses found to be safe and by keeping well within their limits the uncertainty about the action of steel springs may be dismissed as no greater than that attached to any other element of machine construction.

Of course, it is important to have the load central on any jarring machine and since there is no difficulty about locating it in that position, it is hardly worth while to consider at length the effect of eccentric loads. That a reasonable amount of displacement does not appreciably affect the action of the shockless machine is shown by shifting the sand in a large flask.

It must be apparent to anyone who considers the subject that the table itself causes a greater intensity of pressure on the buffer ring between it and the anvil than any amount of sand piled upon the table, and that this blow is central in a properly constructed machine. This solid blow, delivered by comparatively unyielding parts, is sharp and its effect is short-lived, but it is followed immediately by pressure due to the arrested momentum of the flask and sand, which is much less intense and of much greater duration especially during the early stages of the jarring process. No trouble has arisen from this cause and none is to be feared, especially as there are several expedients which may be easily and effectively applied if thought necessary to absorb these little eccentric effects.

In regard to the effect of sand and dust, I do not pretend to say that these elements are worth much as lubricants for machinery, but I can refer to a table of the type described in my paper which has been in successful operation for more than three years, and I must

emphatically deny that dust can work in where air under pressure is working its way out. In the machine which exhausts through the anvil cylinder, I prefer to leave the drip cock open or simply use an open pipe through which part of the air and all the entrained water is continuously passing while the machine is running. There is, therefore, less danger from sand and dust in the working of the shockless machine than in other types.

In regard to the value of pattern-drawing appliances on molding machines, it is quite true that in some cases this work can be done well enough by a crane if the user of the machine is in no hurry, but if he wants quick and efficient service he will find that the crane must be attached to his machine and have nothing else to do. Otherwise more time may be wasted in waiting for the crane than is saved by power ramming and but little advantage will be found from the use of the molding machine. My object in referring to pattern-drawing appliances attached to jarring machines was to illustrate the great advantage of the combination over the advantage to be derived from each element independently. In other words, it pays to bunch hits in efficiency as well as in base-ball and the figures I have given, whether actually realized or not, illustrate this point.

In regard to the tabulated efficiencies of various weights of anvil it must not be forgotten that shockless anvils can, like plain anvils, be made just as heavy as the customer wants to pay for. It is true for both types of machines that the heavier the anvil the greater the efficiency, but in the shockless machine the same efficiency can be realized with less than half the weight required for a plain machine and when air is expanded into the anvil cylinder the efficiency of the shockless machine is still further augmented.

GAS POWER SECTION
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ARTICLES IN PERIODICALS

AEROPLANES AND AIRSHIP ENGINES. *Machinery (English Edition), January 1911.* 4 pp., 13 figs. *bdf.*
Details and description of different types.

BRAKE, CALCULATING H.P. BY PRONY, Charles O. Alexander. *Gas Power, January 1911.* 2 pp.

BRAKING WITH THE ENGINE, Charles Clinton Cowle. *The Gas Engine, December 1910.* 2 pp.
Describes method of using engine as its own brake.

COMPRESSION, LOST, C. R. McGohey. *Gas Power, January 1911.* ¾ p.
Effect of worn bearings on compression.

COOLING GAS ENGINES, G. H. Murdock. *The Gas Engine, November 1910.* 4 pp., 3 figs.
Cooling system as applied to small engines

COSTS, GAS POWER PLANT, R. S. Manning. *Power, December 6, 1910.* 1 p., 2 tables.
Fuel and installation costs of a station consisting of two twin-tandem double-acting horizontal Allis-Chalmers gas engines supplied from Loomis-Pettibone bituminous producers and direct connected to 1000-kw. generators.

ENGINE, A NEW GERMAN GAS. *The Iron Age, January 5, 1911.* 2⅓ pp., 6 figs. *b.*
Details of the double-acting four-cycle engine built by Ehrhardt and Sehmer.

ENGINE PLANT, AN 1800-H.P. GAS, M. S. Smith. *The Gas Engine, November 1910.* 2 pp.
Cleaning of the gas from soft coal producers, and scrubbers used.

ENGINE PRACTICE, MODERN GAS. *The Gas Engine, November 1910.* 3 pp., 3 tables.
Gas consumption, thermal efficiency and notes on operating.

ENGINE, THE HERMAN AERIAL GASOLINE. *The Iron Age, November 3, 1910.* 1 p., 1 fig.

ENGINE, THORNYCRAFT MARINE-OIL. *Engineering (London), October 28, 1910.* 1 p., 3 figs. *bC.*
Exhibited at North-Sea Fisheries, Great Yarmouth.

ENGINE, WILLANS AND ROBINSON'S TWO-STROKE CYCLE ENGINE. *Power, November 1, 1910.* 2 pp., 2 figs.

Flywheels for Internal-Combustion Engines, Proportions and Design, D. O. Barrett. *Machinery, November 1910.* 2 pp., 2 figs.

Governing Mechanisms for Gas Engines, Modern, W. H. Miller. *Power, October 18, 1910.* 4 pp., 10 figs. *bf.*

Ignition Circuits, Emergency and Alarm Systems for, W. T. Garlitz. *Power, November 22, 1910.* 1 p., 1 fig.

Lignite as Fuel, Performance of a Gas Power Plant Using, A. M. Levin. *Power December 27, 1910.* 3 pp., 1 fig., 6 tables.
Results of tests.

Lubrication, J. N. Bagley. *Gas Power, November 1910,* 1½ pp.
Necessity and results of decreasing friction.

Oil Engine at Florence, Colo., Experimental Installation and Test of De La Vergne. *The Gas Engine, December 1910.* 3 pp., 1 fig., 1 table.
An interesting feature in connection with this test is that while the efficiency of gas engines at the altitude of Florence,Colo., is only 80 per cent, the engine in question is competent to assume an overload of 10 per cent and give an efficiency of 88 per cent net h.p.

Oil Motors for Fishing Boats. *Engineering (London), November 4, 1910.* 1 p. *bC.*
Description of marine oil motors exhibited at North Sea Fisheries and Shipping Exhibition at Yarmouth.

Oil Water Gas Plant, Low-Conde, H. B. MacFarland. *Gas Power, January 1911.* 1 p.

Packing Gas Engine, George Cormack, Jr. *Gas Power, December 1910.* 2 pp.
Experiences from cheapest to best.

Pumps and Compressors, Humphrey, Herbert A. Humphrey. *Engineering (London), November 18, 1910.* 4⅓ pp., 20 figs., 5 curves. *bA.*
A very complete paper on this interesting pump.

Producer Design and Operation, Gas. Some Considerations Affecting their Success, P. Von Zeipel. *The Iron Age, November 17, 1910.* 2 pp., 5 figs. *abdf.*
Notes on operating difficulties, progress in designing and history.

Producer, Elementary Lectures on the Gas, C. P. Poole. *Power, December 6, 1910.* 1⅓ pp., 3 tables.
Specific heat of gases.

Pumps for Chingford Reservoir, Gas. *The Engineer (London), November 11, 1910.* ⅓ p., *bC.*
Short account of the letting of contract for Chingford reservoir to have capacity of 180,000,000 gal. in 24 hours.

Power, Some Pertinent Features Relating to Gas, E. D. Dreyfus. *The Electric Journal, January 1911.* 11 pp., 3 figs., 3 tables, 3 curves.
Types of engines and producers and station operating costs.

Tractor, English Oil, Frank C. Perkins. *Gas Power, November 1910.* 1 p., 1 fig.
Efficiency of the oil tractor on the farm.

Turbine, The Gas, F. R. Low. *Power, November 1, 1910.* 1 p.
On Armengaud and Lemale turbine.

GENERAL NOTES

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The Pittsfield-Schenectady Mid-Year Convention of the American Institute of Electrical Engineers opened on Tuesday afternoon, February 14, at the Mohawk Golf Club, Schenectady, with two technical sessions, occupying the afternoon and evening. E. A. Baldwin, Chairman of the Local Committee, made an address of welcome, and the convention was formally opened by the President of the Institute, Dugald C. Jackson, Mem.Am.Soc.M.E. Technical papers were presented upon High Tension Testing of Insulating Material, by A. B. Hendricks; Hysteresis and Eddy Current Exponents for Silicon Steel, by W. J. Wooldridge; Commercial Problems of Transformer Design, by H. R. Wilson; Design, Construction and Tests of an Artificial Transmission Line, by J. H. Cunningham; Protection of Electrical Transmission Lines, by E. E. F. Creighton; Tests of Grounded Phase Protector on the 44,000-Volt System of the Southern Power Company, by C. I. Burkholder and R. H. Marvin; Tests of Losses on High Tension Lines, by G. Faccioli. On Wednesday, February 15, a special train left Schenectady for Pittsfield at 8.30, making a short stop at Albany. On arrival in Pittsfield, a tour of inspection was made of the General Electric Company's works. A professional session occupied the afternoon, papers being presented upon Mechanical Forces in Magnetic Fields, by C. P. Steinmetz, Mem.Am.Soc.M.E.; Problems in the Operation of Transformers, by F. C. Green; The Regulation of Distributing Transformers, by C. E. Allen; Temperature Gradient in Oil-Immersed Transformers, by James Murray Weed; Dissipation of Heat from Self-Cooled, Oil-Filled Transformer Tanks; by J. J. Frank and H. O. Stephens. A dinner was given in the evening in the Hotel Wendell and the party returned to Schenectady by special train. The concluding session occupied Thursday morning, and included papers on Oil-Break Circuit Breakers, by E. B. Merriam; Proposed Applications of Electric Ship Propulsion, by W. L. R. Emmet, Mem.Am.Soc.M.E.; Voltage Regulation of Generators, by H. A. Laycock; and Briefs on Vector Rotation, by E. J. Berg and W. S. Franklin.

AMERICAN INSTITUTE OF MINING ENGINEERS

At the annual business meeting of the Corporation of the American Institute of Mining Engineers on February 21 at the Institute headquarters in New York, the following officers were elected: President, Charles Kirchhoff, Mem.Am.Soc. M.E.; Secretary, R. W. Raymond; Vice-Presidents, S. B. Christy, W. A. Lathrop and Gardner F. Williams; Councillors, A. E. Carlton, W. J. Olcott and E. L. Young.

On June 6, the institute will hold a meeting in the Pennsylvania anthracite region, where it was organized at the Wilkes-Barre meeting of May 1871. Headquarters will be the Glen Summit Springs Hotel, Luzerne County, Pa., near Wilkes-Barre.

Plans are also in progress for a meeting at San Francisco, Cal., in the earlier half of October 1911, which will probably include a visit en route to the Grand Cañon. After the close of the San Francisco meeting an excursion to Japan is contemplated, sailing from San Francisco October 17, in the 27,000-ton Pacific Mail Steamship Manchuria, arriving at Yokahama November 3, and returning November 21. The dates are arranged with a view to witnessing the festivities connected with the birthday of the Mikado.

AMERICAN SOCIETY OF CIVIL ENGINEERS

At the bi-monthly meeting of the American Society of Civil Engineers on February 1, George Robert Graham Conway presented his paper on The Water-Works and Sewerage of Monterey. On February 15, Water Purification Plant, Washington, D. C., Results of Operation, by E. D. Hardy, was considered. The meeting of March 1 will be devoted to a paper by Albert R. Raynor, The Pittsburg and Lake Erie Railroad Cantilever Bridge over the Ohio River at Beaver, Pa.

NEW MECHANICAL ENGINEERING LABORATORIES OF UNIVERSITY OF NEBRASKA

The new mechanical engineering laboratories of the University of Nebraska were formally dedicated on January 18, 1911, with impressive ceremonies. The building, which is one of the finest of the university group and has over-all dimensions of 192 by 160 feet, is executed in brown pressed brick with terra cotta trimmings. In addition to the class rooms and offices of the department, it contains the power, fuel testing, wood working, foundry, forging and machine tool laboratories, with a thoroughly modern equipment.

The program of the day included a series of addresses to engineering students in the forenoon, by J. A. L. Waddell of Kansas City, Mo., Bion J. Arnold of Chicago, and M. E. Cooley, Mem.Am.Soc.M.E., Dean of the College of Engineering of the University of Michigan. At noon a luncheon was served by the Men's Faculty Club to the distinguished visitors, at which was announced the gift of three scholarship funds. During the afternoon the building was thrown open to inspection by the public. The formal dedicatory exercises occupied the evening and included brief addresses by Charles S. Allen, President of the Board of Regents, and Samuel Avery, Chancellor of the University. The principal address of the day was delivered by W. F. M. Goss, Mem. Am. Soc. M. E., Dean of the College of Engineering of the University of Illinois, on The College of Engineering as a Feature in General Education. At the close honorary degrees were conferred on B. J. Arnold, M. E. Cooley, Mem.Am.Soc. M.E., and J. A. L. Waddell.

WORK OF THE NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION

The National Society for the Promotion of Industrial Education has recently issued a pamphlet setting forth the aims and activities of the society and outlining its work for 1911. In a very concise way this pamphlet describes the need for industrial education to meet modern conditions of manufacturing and to enable the United States to compete in the markets of the world, and points out the need for a society especially devoted to the promotion of industrial education for the organized awakening of public interest. The society is now entering the fiftieth year of its existence. Its officers are: President, James P. Munroe, of Boston; Vice-President, Frederick A. Geier, Mem.Am.Soc.M.E., of Cincinnati; Treasurer, Frederic B. Pratt, of Brooklyn; Secretary, Edward H. Reisner, New York.

CANADIAN SOCIETY OF CIVIL ENGINEERS

At the twenty-fifth annual meeting of the Canadian Society of Civil Engineers at Winnipeg, Manitoba, January 24-27, 1911, committee reports on Railway Ties, on Rails, Fastenings, and Tie-Plates, and on other subjects, were received and considered. The address of the retiring president, Col. H. N. Ruttan, Chartering, Location and Construction of Railways, was delivered on Thursday morning. Among the papers presented were a description of the Winnipeg Municipal Power Plant, now under construction, by W. G. Chace; and one upon the Hydro-Electric Development Work of the British Canadian Power Company in the Cobalt District, by A. L. Mudge. The officers elected for the ensuing year are, C. H. Rust, President, and Henry Holgate and C. E. W. Dodwell, Vice-Presidents.

KANSAS ENGINEERING SOCIETY

At the annual meeting of the Kansas Engineering Society held in Topeka, Kansas, January 20 and 21, papers were presented upon the Evolution of Highway Bridge Construction, W. H. Jones; Surveys, J. W. Mavity; First Transportation, J. M. Meade; Stream Pollution and Sewerage, W. C. Hoad; Value of Pure Water, R. E. McDonnel; Foundations, H. S. Tullock; and other subjects of interest.

OHIO ENGINEERING SOCIETY

On January 24–26, the Ohio Engineering Society held its thirty-second annual meeting in Columbus, Ohio. Much time was devoted during the convention to the discussion of the proposed bill recently introduced into the Ohio State Legislature, providing for the registration and examination of civil and mining engineers and surveyors, and a resolution was adopted endorsing the bill. Among the papers presented were, Construction of Bituminous Macadam Roads, Jas. T. Voshell; Road Laws of Ohio, J. C. Wonders; Province of Disinfection, Clyde Potts; Some Features of Design of Filtration Plants, Philip Burgess; and a symposium on Operation of Sewage Purification Works, by Paul Hansen, Wm. H. Dittoe, and R. W. Ferris. The following officers were elected for the ensuing year: President, Hugh K. Lindsay; Vice-President, Frank R. Landor; Secretary-Treasurer, C. J. Knisely.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS

At the twenty-seventh annual meeting of the Connecticut Society of Civil Engineers, held in New London on February 14 and 15, 1911, officers were elected for the ensuing year.

At the afternoon session of the opening day addresses were made by Alfred D. Flinn of the Board of Water Supply of New York, on The Catskill Water Works for New York, and by Herbert M. Knight, formerly with the Sewerage Commission, on Some Features of Baltimore's Ten Million Dollar Sewerage System. Both were illustrated with lantern slides. Wednesday morning was occupied with papers on Testing Water Wheels after Installation, by Chas. M. Allen, Mem.Am.Soc.M.E.; The Relation of the Weather and Forestization to Stream Flow, by Willis L. Moore of the Department of Agriculture; and Actual Yield of a Typical Connecticut Watershed, by R. A. Cairns. Other events of the convention were an excursion to the water works high service pumping station, and an informal dinner.

IOWA ENGINEERING SOCIETY

The twenty-third annual meeting of the Iowa Engineering Society was held on February 15-17, 1911, at Des Moines, Iowa. At the opening session on Wednesday, the Mayor of Des Moines welcomed the society, and a symposium on the Statutory Regulation of Engineering Work was presented by T. R. Warriner, W. G. Raymond, Lafayette Higgins and Anson Marston. Thursday was occupied with two sessions, one in the morning on Drainage, with papers on Tile Drainage, by J. L. Parsons, Results of Experience for Tests of Drain Tile and Sewer Pipe, by Anson Marston, Public Work vs. Politics, by K. C. Gaynor; and another in the afternoon on Sanitary Engineering, with papers on Sewage Purification and Disposal, by Chas. P. Chase, Practical Points in Sewer Construction, by Lowell H. Stone, New Rapid Sand Filters at Iowa City, by J. H. Dunlap, Water Power Development in Iowa, by Arthur H. Ford, and a Review of Investigations of the Recent Typhoid Epidemic in Des Moines, by Lafayette Higgins. On Thursday evening George P. Dieckmann delivered an illustrated lecture on Modern Manufacture of Portland Cement. On Friday, following a business session, a number of papers were presented, among them, Does the Boulevard Lighting System Pay? by Austin Burt; Road Building in Germany, B. Schreiner; Discrepancies in Cement Testing, F. C. Young; and Cement Concrete Street Paving in Mason City, Fred P. Wilson. The afternoon was occupied in a visit to the large new cement factory of the Iowa Portland Cement Company, where cement is manufactured upon a large scale by the most modern methods.

ENGINEERS CLUB OF PHILADELPHIA

The Engineers Club of Philadelphia held its thirty-second annual meeting on February 4, 1911, at 8.30 p. m. The business of the evening included the election of officers, which resulted as follows: President, James Christie, Mem. Am.Soc.M.E.; Vice-President, W. L. Pack; Secretary, W. Purves Taylor; Treasurer, F. H. Stier. The annual address was delivered by the retiring president, Wm. Easby, Jr., on The Beginning of Sanitary Science and the Development of Sewerage and Sewage Disposal.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

The following officers were elected at the annual meeting of the American Society of Heating and Ventilating Engineers, held in the Engineering Societies Building, January 24-26, 1911: President, R. P. Bolton, Mem. Am. Soc.M.E.; 1st Vice-President, John R. Allen; 2d Vice-President, A. B. Franklin; Secretary, W. W. Macon, Jun.Am.Soc.M.E.; Treasurer, U. G. Scollay. This was reported in an incorrect form in The Journal for February.

PERSONALS

J. F. Beecher, has become connected with the Tennessee Coal, Iron & R. R. Co., Birmingham, Ala., in the capacity of checker of the coke oven department. Mr. Beecher was formerly associated with the Indiana Steel Co., Gary, Ind.

Charles O. Churchill has been appointed president and secretary of the Westfield Foundry & Valve Co., Westfield, Mass. He was until recently superintendent of the Georgian Manufacturing Co., Binghamton, N. Y.

F. H. Clark, general superintendent of motive power, Chicago, Burlington & Quincy R. R. Co., Chicago, Ill., has become identified with the Baltimore & Ohio R. R., Baltimore, Md., in a similar capacity.

William Darbee, formerly assistant general manager of the Consolidated Gas, Electric Light & Power Co. of Baltimore, Md., has become connected with the Electric Bond & Share Co., New York.

Geo. T. Frankenberg has accepted a position with the Cambria Steel Co. as general outside foreman of the Cambria Works. Until recently he was connected with the Ralston Steel Car Co., Columbus, O.

W. S. Hazelton has been appointed manager of the Chicago office of the Corrugated Bar Co.

Prof. Frederick R. Hutton, Hon. Secy., Am.Soc.M.E. has been appointed consulting engineer in the Department of Water Supply, Gas and Electricity, New York.

Sherwood F. Jeter has resigned from the position of mechanical engineer for the Bigelow Co., New Haven, Conn., a position he has held for the past five years, to become supervising inspector for the Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn.

An account of Prof. William Kent's impressions of the engineering features of the Panama Canal has been published in the December 27 issue of the South American Supplement of The Times, London, England.

S. L. G. Knox, recently associated with M. Burr, Jr., & Co., New York, has become consulting engineer of the Hammon Engineering Co., San Francisco, Cal.

Wm. W. Macon, managing editor of The Metal Worker, has been elected secretary of the American Society of Heating and Ventilating Engineers.

W. P. Pressinger, having sold his interest in the Keller Manufacturing Co. of Philadelphia, Pa., has resigned as vice-president to again become manager of the compressor department of the Chicago Pneumatic Tool Co., with headquarters in New York.

Henry B. Seaman, who recently resigned as chief engineer of the Public Service Commission for the first district, New York, has resumed private practice with offices in New York.

Grant B. Shipley, formerly engineer of the mining and timber preserving machinery for the Allis-Chalmers Co., Milwaukee, Wis., is now president of the Pittsburg Wood Preserving Co.

John Vandemoer has become associated with the El Paso Smelting Works, El Paso, Tex. He was formerly identified with the Cia. Metalurgica Nacional, Matehuala, S. L. P., Mexico.

W. H. Whiteside recently resigned from the presidency of the Allis-Chalmers Co., Milwaukee, Wis.

Francis H. Wisewell, formerly of Westinghouse, Church, Kerr & Co. and of the International Heater Co., has been elected vice-president of the Mohawk Valley Heating Co., Utica, N. Y.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society, included in the Engineering Library. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary, Am.Soc.M.E.

ACADEMIC AND INDUSTRIAL EFFICIENCY. A report to The Carnegie Foundation for the Advancement of Teaching. By M. L. Cooke. (Bulletin No. 5.) *New York, 1910.* Gift of the author.

AMERICAN BLACKSMITH. Vols. 2, 4, 6, 7. *Buffalo, 1902-1908.*

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The Journal. Nos. 7–12. July-December, 1910. *New York, 1910.*

AMERICAN WATER WORKS ASSOCIATION. Proceedings of 30th annual convention, 1910. *1910.* Gift of the association.

ART OF AVIATION. By R. W. A. Brewer. *New York, McGraw-Hill Book Co., 1910.* Gift of publishers.

BARGE CANAL BULLETIN. Department of the State Engineer and Surveyor of the State of New York. December 1910. *Albany, 1910.* Gift of New York State Engineer.

CENTRAL FOUNDRY COMPANY. Plan and Agreement of Reorganization. Dated January 3, 1911. *New York, 1911.* Gift of the company.

CONCERNING THE FACTORY MUTUALS AND CERTAIN NEW LEGISLATION. *Providence, R. I., 1910.* Gift of C. W. Rice.

EFFICIENCY AS A BASIS FOR OPERATION AND WAGES. By Harrington Emerson. *New York, Engineering Magazine, 1909.*

ELECTRICITY UNCOVERS A LAW OF EVOLUTION. By George Iles. *1909.* Gift of the author.

GYPSUM AS A FIREPROOF MATERIAL. By H. G. Perring. *Chicago, 1910.* Gift of the author.

HEAT INSTALLATIONS. By W. D. Allen. *Seattle.* Gift of C. W. Rice.

HYDRAULIC TURBINES, THEIR DESIGN AND INSTALLATION. By Viktor Gelpke and A. H. Van Cleve. *New York, McGraw-Hill Book Co., 1911.*

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS. Proceedings of the 15th annual convention. *Rochester, 1910.* Gift of the association.

INTERNATIONAL CONGRESS OF NAVIGATION, 12TH. First Circular for Circulation in the United States. *Philadelphia, 1910.* Gift of the Congress.

INTRODUCTION TO THERMODYNAMICS FOR ENGINEERING STUDENTS. By John Mills. *Boston, Ginn & Co., 1910.*

ISSUANCE OF STOCKS AND BONDS OF AMERICAN RAILWAYS. Letter to the Railroad Securities Commission in Reply to their Request for Information and Opinions upon Questions Pertaining to. By W. H. Williams. January 18, 1911. *New York, 1911.* Gift of the author.

LOGICAL BASIS FOR VALUATIONS OF INTERURBAN STREET RAILWAYS. By C. G. Young. (Reprint of paper read at the Annual Meeting of the Central Electric Railway Association, January 19, 1911.) Gift of the author.

Manual of Marine Engineering. By A. E. Seaton. ed. 16. *London, Chas. Griffin & Co., 1907.*

Marine Boilers, their Construction and Working, Dealing more especially with Tubulous Boilers, based on the work by L. E. Bertin. Translated and edited by L. S. Robertson. ed. 2. *New York, D. Van Nostrand Co., 1906.*

Motor Load of Massachusetts Central Stations. By W. S. Kelley. (Reprinted from Electrical World, Oct. 6, 1910.) Gift of the author.

National Association of Cement Users. List of Members and General Information, July 1910. *Philadelphia, 1910.* Gift of the association.

Pennsylvania Railroad Company, Test Department. Locomotive Testing Plant at Altoona, Pennsylvania Tests of an E2A Locomotive, 1910. *Altoona, 1910.* Gift of the company.

Pocket Book of Mechanical Engineering. By C. M. Sames. ed. 4. *Jersey City, N. J., 1911.* Gift of the author.

Principles and Design of Aeroplanes. By Herbert Chatley. *New York, D. Van Nostrand Co., 1911.*

Profit Making in Shop and Factory Management. By C. U. Carpenter. *New York, Engineering Magazine, 1908.*

Scientific American Supplement. Catalogue. 1897–1910. *New York.* Gift of Munn and Company.

Short History of the Printing Press and of the Improvements in Printing Machinery from the Time of Gutenberg up to the Present Day. *New York, 1902.*

Société Technique de l'Industrie du Gaz en France. Compte Rendu, Vols. 1–14, 29. *Paris, 1878-1887, 1902.*

Society for the Promotion of Engineering Education. Year Book. 1911. *Lancaster, 1911.* Gift of the society.

Some Glimpses of Commerical Economics. (Paper read by W. J. Clark before the Worcester Board of Trade, January 7, 1911.) Gift of the author.

Standard Specifications for Structural Steel, Timber, Concrete and Reinforced Concrete. By J. C. Ostrup. ed. 2. *New York, McGraw-Hill Book Co., 1911.*

Standardization of Locomotives in India. By Cyril Hitchcock. (Read before Meeting of the Local Section of The Institution of Mechanical Engineers, at Calcutta, Nov. 23, 1910.) Gift of the institution.

Steam Turbines, their Design and Construction. By Rankin Kennedy. *New York, Macmillan Co., 1910.*

Street Railway Association of the State of New York. Report of the 28th annual meeting, 1909–1910. *Kingston, 1910.* Gift of the association.

Tufts College. Annual Catalogue, 1910–1911. *Boston, 1910.*

Vassar College. 46th Annual Catalogue, 1910-1911. *Poughkeepsie, 1910.*

Work, Wages and Profits. Their Influence on the Cost of Living. By H. L. Gantt. *New York, Engineering Magazine, 1910.*

Yale University. General Catalogue, 1910–1911. *New Haven, 1910.*

EXCHANGES

CANADIAN MINING INSTITUTE. Journal. Vol. 13. 1910. *Montreal, 1911.*

INSTITUTION OF CIVIL ENGINEERS. List of Members, Jan. 2, 1911. *London, 1911.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings. Vol. 182. *London, 1910.*

——Address of Alexander Siemens, President. Nov. 1, 1910. *London, 1910.*

——Report of the Proceedings at the Ceremony of Laying the Foundation Stone of the New Building, Oct. 25, 1910. *1910.*

INSTITUTION OF GAS ENGINEERS. Transactions. 1910. *London, 1910.*

U. S. LIBRARY OF CONGRESS. Report of the Librarian, 1910. *Washington, 1910.*

TRADE CATALOGUES

W. D. ALLEN, *Seattle, Wash.* Heat installations in modern buildings, 11 pp.

ALLIANCE MACHINE CO., *Alliance, O.* Electric cranes, charging machines, punches and shears, 88 pp.

C. L. BARKER, *Norwalk, Conn.* Catalogue J, Barker Motors, 28 pp.

BAUSCH & LOMB OPTICAL CO., *Rochester, N. Y.* Baloptical, model C, for general projection work, 16 pp.

BRETZ CO., *New York.* Ball bearings, 20 pp.; F. &. S. annular ball bearings, 8 pp.; thrust bearings, 3 pp.; annular ball bearings, magneto type, 3 pp.; single annular type ball bearings, 7 pp.; list of automobile makers using F. & S. ball bearings, 3 pp.; price list, 6 pp.; various styles of ball bearings, 116 pp.; German edition of Bretz, F. & S. ball bearings, 176 pp.

BRISTOL CO., *Waterbury, Conn.* Bull. no. 130, Indicating and recording electric pyrometers, 47 pp.

CHICAGO PNEUMATIC TOOL CO., *Chicago, Ill.* Franklin air compressors, 96 pp.

CRANE CO., *New York.* Complete pocket catalogue of standard pressure valves, cocks, fittings, steam supplies, 464 pp.

DUCKER CO., *New York.* Sectional and ready-made Ducker houses, 22 pp.

ELECTRIC CONTROLLER & MFG. CO., *Cleveland, O.* Common Sense, December 1910.

CHARLES ENGELHARD, *New York.* Heraeus-LeChatelier pyrometer, 83 pp.; guide to installation of pyrometer, 17 pp.; electrically-heated furnace for high temperatures, 10 pp.; apparatus made of melted rock crystal, 3 pp.; pure silica ware, 6 pp.; Heraeus electric muffle furnace, 8 pp.

A. FREUNDLICH, *Düsseldorf, Germany.* Ammunition cooling plant on board warships, 8 pp.

GANDY BELT CO., *Baltimore, Md.* Belts and belting, 6 pp.

GENERAL ELECTRIC CO., *Schenectady. N. Y.* Illuminous and flame arcs *vs.* open and enclosed carbon arcs for street illumination, 28 pp. Bull. no. 4685, Belt-driven alternators, 11 pp.; Bull. no. 4804, Direct-connected generating sets, 11 pp.; Bull. no. 4810, Portable and stationary air compressors, 7 pp.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.,* Catalogue of ball and roller bearings, 64 pp.

HILLIARD CLUTCH & MACHINERY CO., *Elmira, N. Y.* Friction clutch and cut-off coupling, 6 pp.

H. W. JOHNS-MANVILLE CO., *Cleveland, O.* J-M Roofing Salesman, January 1911, 8 pp.

LAGONDA MFG. CO., *Springfield, O.* Turbine boiler tube cleaners, 48 pp.

F. E. MYERS & BROS., *Ashland, O.* Catalogue no. 49, Pumps, hay unloading tools, barn door hangers, agricultural implements, 404 pp.

PHILADELPHIA GEAR WORKS, *Philadelphia, Pa.* Catalogue, 76 pp.

B. F. STURTEVANT CO., *Hyde Park, Mass.* Fuel economizers and air heaters, 40 pp.

TECHNICAL DATA & APPLIANCE CO., *Chicago, Ill.* Data, November 1910, 62 pp.

UNITED ENGINEERING SOCIETY

DIRECTORY OF DIRECTORS IN THE CITY OF NEW YORK. 1909-1910. *New York, Audit Company of New York, 1910.*

OKLAHOMA GEOLOGICAL SURVEY. Director's Biennial Report to the Governor, 1910. (Bulletin no. 6.) *Norman, 1910.*

WILLING'S PRESS GUIDE, 1911. *London, 1911.*

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

071 Superintendent of machine shop, building high speed automatic engines experience in handling workmen on the premium or bonus systems. Should have had experience in designing jigs for duplicate work and reducing shop costs. Technical education necessary. Location central Illinois.

072 A leading high speed engine builder is in need of an experienced superintendent and designing engineer; must be familiar with best modern shop practice, and have had previous experience in steam engine design. Salary not so much of a consideration as ability. Do not wish to correspond with anyone not receiving a good salary now. Location Pennsylvania.

073 Inspector wanted by power company; applicant should be a graduate of technical school with three or more years experience in drafting rooms and shops of railroads or concerns manufacturing heavy machinery. Location New York State.

074 Member desires to join consulting engineer who either from age or other reasons would wish to take partner into his employ or have associated with him. Compensation secondary consideration to prospects. Location Philadelphia or New York preferred.

075 First class man to represent firm in connection with agents in the middle west. College graduate, thirty years of age or over, thorough knowledge of machine shop practice and machine tools. Business will be to go into machine shops and recommend proper machines and equipment for increasing output.

076 Works manager competent to direct design and construction of apparatus involving small parts. Must be competent to manage two large factories, separated some distance from each other. Salary $6000 to $10,000.

077 Graduate M. E., as assistant superintendent in manufactory of creamery and dairy apparatus and general woodwork, employing upwards of

100 men. Must be quick to detect imperfections, tactful and patient with men, an organizer; assist in matters pertaining to introduction of modern methods of scientific factory management and cost-keeping. Location Vermont. Salary to begin, $1000 per year.

078 Engineering salesman; young man, technical graduate preferred, to sell well-known line of special machinery. State experience and salary expected.

MEN AVAILABLE

172 Mechanical and electrical engineer, six years experience in teaching engineering at state universities, two years head of department, last four years in practical professional lines, desires communication with educational institution wishing the services of a high grade man. Prefers to teach in the line of machine design or electrical engineering.

173 Technical graduate, mechanical and electrical engineering, married, eight years experience, in large mill on automatic machinery construction, contracting and charge of drafting room, desires position in Massachusetts. Best of references. Understands latest methods of mill systems.

174 Mechanical engineer with several years experience in engine works; past ten years head of strong engineering college in prominent university desires a change. Responsible teaching position preferred.

175 Junior member, at present employed, graduate in mechanical engineering, taught machine design one year; one year technical drafting; desires position as assistant to works superintendent or industrial engineer. Salary, $1400.

176 Manager for company, 25 years in East, in machine tool line, desires position as sales manager. Extensive acquaintance and experience in selling machinery throughout United States and Canada.

177 Graduate mechanical engineer, Mass. Inst. Tech.; three years teaching engineering subjects; two years in practical work in New York. At present engaged in research work for degree of M.M.E. Desires position as professor in steam engineering.

178 Sales engineer, would consider position where knowledge of machinery and mill supply trade of the United States and Canada is essential; seven years varied engineering experience; six years in selling end. Experience in correspondence and design of selling contracts.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ADAMS, Edward T. (1899), Pres., Wisconsin Eng. Co., Corliss, and 539 Terrace Ave., Milwaukee, Wis.

BAXTER, Burke Morgan (Junior, 1908), Mech. Engr. with H. B. Prather, Cons. Engr., 662 Rockefeller Bldg., and *for mail*, 1803 Wilton Road, Cleveland, O.

BEECHER, J. F. (Associate, 1908), Checker, Coke Oven Dept., Tennessee Coal, Iron & R. R. Co., and *for mail*, 2025 Fifth Ave., Birmingham, Ala.

BIRDSEY, Charles Robt. (Associate, 1907), Ch. Engr., U. S. Gypsum Co., 200 Monroe St., and *for mail*, 503 S. Central Park Ave., Chicago, Ill.

CAMERON, Barton H. (1903), Pres., Cameron Stove Co., Box 635, and *for mail*, 1804 Hanover Ave., Richmond, Va.

CASE, Albert H. (Junior, 1903), Supt., Santa Fé Gold & Copper Min. Co., San Pedro, New Mex., and *for mail*, P. O. Box 164, Philipsburg, Pa.

CHURCHILL, Charles O. (1906), Pres. and Secy., Westfield Fdy. & Valve Co., Westfield, Mass.

CLARK, Frank Henry (1910), Genl. Supt., M. P., B. & O. R. R., Baltimore, Md.

COLLINS, B. R. T. (1891; 1901), 19 Congress St., Boston, Mass.

COX, Frederick W. (1908), present address unknown.

CREELMAN, Frank (1894), 447 W. 23d St., New York, N. Y.

DARBEE, William (Junior, 1900), Elec. Bond & Share Co., 71 Broadway, New York, N. Y.

DONNELLY, William T. (1903), Cons. Engr., 17 Battery Pl., New York, N.Y.

FERGUSSON, Henry A. (1902), Cons. Engr., and Genl. Mgr., Steel Roof Truss Co., Valley Park, and 505 Lockwood Ave., Webster, Mo.

FRANKENBERG, George T. (Associate, 1907), Genl. Outside Foreman, The Cambria Steel Co., and *for mail*, 522 Second Ave., Westmont, Johnstown, Pa.

GILLAN, Howard A. (Junior, 1907), Mech. Engrg. Dept., N. Y. C. & H. R. R. R. Co., 42d St., and *for mail*, 660 W. 179th St., New York, N. Y.

GRAY, William Emery (1907), Genl. Sales Mgr., The Enameled Pipe & Engrg. Co., Elyria, O.

HAZELTON, WILLIAM S. (1909), Mgr., Chicago Office, Corrugated Bar Co., 1825 Commer. Natl. Bank Bldg., Chicago, Ill.

HENRY, Geo. J., Jr. (1901), Ch. Engr., Pelton Water Wheel Co., 19th and Harrison Sts., and 3999 Clay St., San Francisco, Cal.

HERRESHOFF, J. B. Francis (1894), V. P., Nichols Copper Co., Cons. Engr., Genl. Chem. Co., 25 Broad St., and *for mail*, 620 West End Ave., New York, N. Y.

HERRON, James H. (1897; 1905), Cons. Engr., Engrs. Bldg., and Fairmount Blvd., Shaker Hgts., Cleveland, O.
HOGUE, Oliver D. (1909), Mgr., Power Pump Dept., The Goulds Mfg. Co., 58 Pearl St., Boston, Mass.
HORNE, H. Field (Junior, 1909), Asst. Supt., M. W. Kellogg Co., 117 West Side Ave., Jersey City, N. J., and *for mail*, Mohegan, N. Y.
INGERSOLL, Geo. T. (1903), Worcester, Otsego Co., N. Y.
JETER, Sherwood F. (1909), Supv. Inspr., Hartford Steam Boiler Inspc. & Ins. Co., Hartford, Conn.
JETT, Carter C. (Junior, 1902), 1499 E. 55th St., Cleveland, O.
KENYON, Alfred Lewis (1904), Tallulah Falls, Ga.
KNISKERN, W. H. (Junior, 1905), Secy., Freeborn Engrg. & Constr. Co., 605-615 Scarritt Bldg., and 651 W. 39th St., Kansas City, Mo.
KNOX, S. L. Griswold (1892; 1901), Cons. Engr., Hammon Engrg. Co., Alaska Commer. Bldg., San Francisco, Cal.
MAROT, Edward H. (Junior, 1903), Dist. Sales Mgr., Hyatt Roller Bearing Co., and *for mail*, Genl. Delivery, Newark, N. J.
PALMER, Cortlandt E. (1895), U. S. Express Bldg., 2 Rector St., New York, N. Y.
PARSONS, Willard P. (1884), Secy., Cohoes Co., and 69 Front St., Cohoes, N. Y.
PAUL, John Wallace (1895; 1896), P. O. Box 85, Groton, N. Y.
PRICE, Norman I. (Junior, 1902), Union Bank Chambers, Pitt St., Sydney, Australia.
RENOLD, Charles Garonne (Junior, 1906), Dir., Hans Renold, Ltd., Progress Wks., and 53 Heaton Rd., Withington, Manchester, England.
ROGERS, Robert W. (Junior, 1908), Office of Genl. Mech. Supt., Erie R. R., 50 Church St., New York, N. Y., and *for mail*, 386 Washington Ave., North Newark, N. J.
SARENGAPANI, T. S. (Junior, 1903), Head Draftsman, Kistna Reservoir Project, Madras, India.
SCOTT, Clarence N. (1902), The Texas Co., Houston, Tex.
SHAW, James C. (1909), Engr. and Tech. Adviser, Kawasaki Dockyard Co., Ltd., and 2 Nakayamale Dori 3 Chome, Kobe, Japan.
SMEAD, William H. (Junior, 1906), Engr., West. Htg. and Power Piping Dept., Genl. Fire Extinguisher Co., Warren, O.
SMITH, Ernest L. (1901; 1908), 870 Woodward Ave., Detroit, Mich.
STANTON, Francis A. O'C. (Junior, 1909), City Engr., 1104 Bloomfield St., Hoboken, N. J., and 2 Rector St., New York, N. Y.
TABOR, Leroy (1909), The Tabor Mfg. Co., 18th and Hamilton Sts., Philadelphia, Pa.
THORN, Charles Norman (Associate, 1910), Pur. Agt. and Mech. Engr., Hugh Kelly & Co., 81 Wall St., New York, N. Y.
TURNER, Charles P. (Associate, 1907), 610 Chapel St., Schenectady, N. Y.
VANDEMOER, John (Associate, 1904), El Paso Smelting Wks., El Paso, Tex.
VOSE, Fred Hale (1906; 1910), Mech. Engrg. Dept., Case Sch. of Applied Science, and *for mail*, 9904 Newton Ave., Cleveland, O.
WEHNER, Lewis (1901; 1907), First Asst. Engr., The Bucyrus Co., South Milwaukee, and *for mail*, 508 Cudahy Apts., Juneau Pl. and Mason St., Milwaukee, Wis.

WHITTEMORE, John R. (1902), 230 Madeline Drive, Pasadena, Cal.
WILEY, James M. (Junior, 1909), Holly Sugar Co., Huntingdon Beach, Cal.
WISEWELL, Francis H., Jr. (Junior, 1905), V. P., Mohawk Valley Htg. Co., 22 Broad St., Utica, N. Y.

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DAHLSTRAND, Hans (1910), Mech. Engr., Steam Turbine Engrg. Dept., Allis-Chalmers Co., and *for mail*, 3917 Galena St., Milwaukee, Wis.
HAAS, Lucian L. (Junior, 1910), Ch. Tool Designer, E. R. Thomas Motor Co., and *for mail*, 38 Best St., Buffalo, N. Y.
JONES, Reid (Junior, 1910,) Mech. Engr., San Antonio Water Supply Co., San Antonio, Tex.
ORR, John (1909), Prof. of Engrg., S. A. Sch. of Mines and Tech., P. O. Box 1176, Johannesburg, Transvaal, S. A.
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VARNES, Samuel K. (Junior, 1910), Exper. Engr., Pa. Steel Co., Steelton, and *for mail*, 226 Maclay St., Harrisburg, Pa.
WESTLAKE, Charles Thomas (1910), Ch. Mech. Engr., Commonwealth Steel Co., 1629 Pierce Bldg., St. Louis, Mo.

DEATHS

ALBERGER, Louis R., January 31, 1911.
CORBETT, William H., February 20, 1911.
EDSON, Jarvis B., January 26, 1911.
FREEMAN, Stuart, February 2, 1911.
MORGAN, Charles Hill, January 10, 1911.
NORBOM, John O., January 20, 1911.
SEAVER, John Wright, January 14, 1911.

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ADAMS, Edward T. (1909), Mem.Am.Soc.M.E.
HAYES, Frank A. (Affiliate, 1909), 272 Lafayette Ave., Passaic, N. J.
PAUL, John Wallace (1909), Mem. Am.Soc.M.E.
SUTER, John (Affiliate, 1909), Pittsburg Plate Glass Co., Kokomo, Ind.

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SHATTUCK, John David (Affiliate, 1910,) Gen. Supt., Am. Gas Co., Chester, Pa.

STUDENT BRANCHES

CHANGES OF ADDRESS

BESS, Earl (Student, 1910,) 245 N. D. St., Hamilton, O.
BRUCE, A. C. (Student, 1910), 1301 Dearborn Ave., Chicago, Ill.
CRAIG, W. D. (Student, 1910), 68 Centre St., Woodbury, N. J.
CUMMINGS, C. G. (Student, 1910), 66 High St., Medford, Mass.
ESTEP, Albert B. (Student, 1910), care S. H. Frye, Carnegie, Pa.
GLICK, G. A. (Student, 1910), care G. A. Lowe Co., Ogden, Utah.
GREEN, J. B. (Student, 1910), Sellersburg, Ind.
GRIFFITHS, F. H. (Student, 1909), 3327 Armour Ave., Chicago, Ill.
HERBERT, E. H. (Student, 1909), Doak Gas Eng. Co., 4th and Madison Sts., Oakland, Cal.
LOCKARD, J. P. (Student, 1909), Y. M. C. A. Bldg., Lynn, Mass.
MARGARIDA, Manuel (Student, 1910), 478 Main Bldg., State College, Pa.
MARSH, Karl (Student, 1910), Dominion Iron & Steel Co., Sydney, N. S., Canada.
MATTHAI, A. D. (Student, 1910), 9 Buckingham Rd., Brooklyn, N. Y.
MOORE, R. S. (Student, 1910), 430 Charter St., Madison, Wis.
MUELLER, B. H. (Student, 1910), 1015 W. Johnson St., Madison, Wis.
OGILVIE, George E. (Student, 1910), Genl. Delivery, Lynchburg, Va.
PARSONS, Harry N. (Student, 1909), 48 W. 34th St., Chicago, Ill.
RAHN, Robert M. (Student, 1910), 327 McAllister Hall, State College, Pa.
RUGG, D. M. (Student, 1909), Indiana Steel Co., Gary, Ind.
SHEARER, W. H. (Student, 1910), 127 Third St., Troy, N. Y.
SWIGGETT, C. A. (Student, 1909), 1014 S. Main St., Wichita, Kan.
TAYLOR, John R. (Student, 1910), Blairsville, Pa.
WHEDBEE, Edgar (Student, 1909), 356 Schermerhorn St., Brooklyn, N. Y.
WIEST, Howard N. (Student, 1910), 281 Pleasant St., Milwaukee, Wis.

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ARMOUR INSTITUTE OF TECHNOLOGY

AMBROSE, R. B. (Student, 1911), 6124 Woodlawn Ave., Chicago, Ill.
RUEF, J. (Student, 1911), 721 W. 61st St., Chicago, Ill.
WONG, Yuk (Student, 1911), 3546 Wentworth Ave., Chicago, Ill.

COLUMBIA UNIVERSITY

STONE, E. W. (Student, 1911), 1128 Bedford Ave., Brooklyn, N. Y.

CORNELL UNIVERSITY

COFFIN, W. C. F. (Student, 1911), 116 Oak Ave., Ithaca, N. Y.
CONSTAM, A. F. (Student, 1911), 205 Williams St., Ithaca, N. Y.
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MORSE, D. F. (Student, 1911), 102 Highland Pl., Ithaca, N. Y.
RITSCHARD, V. (Student, 1911), 116 Oak Ave., Ithaca, N. Y.
SMITH, D. F. (Student, 1911), 411 Dryden Rd., Ithaca, N. Y.
ZINK, R. E. (Student, 1911), Hillcrest, Ithaca, N. Y.

LELAND STANFORD JUNIOR UNIVERSITY

CAMPBELL, C. P. (Student, 1911), Stanford Univ., Cal.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DOBLE, R. N. (Student, 1911), 24 South St., Quincy, Mass.
SEATON, Roy A. (Student, 1911), 198 W. Brookline St., Boston, Mass.
SEELEY, N. S. (Student, 1911), 44, The Fenway, Boston, Mass.

PENNSYLVANIA STATE COLLEGE

GROMAN, F. C. (Student, 1911), Alpha Kappa Delta House, State College, Pa.
JONES, H. H. (Student, 1911) 229 W. Beaver Ave., State College, Pa.
KINNEY, J. A. (Student, 1911), 224 Allen St., State College, Pa.
MASON. M. M. (Student, 1911), 418 Main Bldg., State College, Pa.
RHOADS, R. L. (Student, 1911), Phi Tau House, State College, Pa.
ROBINSON, C. A. (Student, 1911), 337 McAllister Hall, State College, Pa.
SCHAEFFER, H. M. (Student, 1911), 237 McAllister Hall, State College, Pa.
WILLIAMS, A. S. (Student, 1911), 352 McAllister Hall, State College, Pa.

POLYTECHNIC INSTITUTE OF BROOKLYN

ENNIS, Roy C. (Student, 1911), Poly. Inst. of Brooklyn, Brooklyn, N. Y.
KOPF, Chas. J. (Student, 1911), Rm. 1061, 200 Fifth Ave., New York, N. Y.

STATE UNIVERSITY OF KENTUCKY

BOYD, J. A. (Student, 1911), 605 S. Limestone St., Lexington, Ky.
CAMPBELL, John (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
CASSIDY, P. R. (Student, 1911), 630 W. High St., Lexington, Ky.
CLEVELAND, M. A. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
DANIEL, C. E. (Student, 1911), 427 S. Upper St., Lexington, Ky.
DAY, O. L. (Student, 1911), Sta. 4, Box 642, Lexington, Ky.
DOUGLAS, E. T. (Student, 1911), Sta. 4, Box 696, Lexington, Ky.
DOWNING, V. L. (Student, 1911), 158 N. Ashland Ave., Lexington, Ky.
DUNCAN, W. C. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
EBBERT, S. C. (Student, 1911), 136 E. Maxwell St., Lexington, Ky.

FITZPATRICK, J. J. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
FOSTER, J. M. (Student, 1911), 315 E. Maxwell St., Lexington, Ky.
HASWELL, A. B. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
LURTEY, W. A. (Student, 1911), Sta. 4, Box 642, Lexington, Ky.
MILES, F. T. (Student, 1911), Sta. 4, Box 651, Lexington, Ky.
MILLS, G. C. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
MOORE, H. Lee (Student, 1911), 315 E. Maxwell St., Lexington, Ky.
NEEDY, J. A. (Student, 1911), Sta. 4, Box 711, Lexington, Ky.
PHISTER, J. B. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
SANDERS, J. B. (Student, 1911), 213 Clay Ave., Lexington, Ky.
SHANKLIN, G. B. (Student, 1911), cor. Maxwell and S. Broadway, Lexington, Ky.
SLADE, Theodore (Student, 1911), 507 N. Broadway, Lexington, Ky.
SMARR, B. M. (Student, 1911), 136 E. Maxwell St., Lexington, Ky.
STEVENSON, W. W. (Student, 1911), 605 S. Limestone St., Lexington, Ky.
WEBB, R. S. (Student, 1911), 353 S. Mill St., Lexington, Ky.

STEVENS INSTITUTE OF TECHNOLOGY

SPILLMAN, Thomas B. (Student, 1911), Stevens Inst. of Tech., Hoboken, N. J.

UNIVERSITY OF ILLINOIS

FAUST, P. A. (Student, 1911), 934 W. Illinois St., Urbana, Ill.

UNIVERSITY OF WISCONSIN

WILSON, H. A. (Student, 1911), 1412 63d Pl., Chicago, Ill.
WOOD, L. A. (Student, 1911), 604 State St., Madison, Wis.

YALE UNIVERSITY

BRISTOL, R. W. (Student, 1911), 112 Sheff. Vanderbilt, New Haven, Conn.
FERGERSON, F. A. (Student, 1911), 152 Sheff. Vanderbilt, New Haven, Conn.
FISHER, R. F. (Student, 1911), 96 Wall St., New Haven, Conn.
HILL, B. W. (Student, 1911), 151 Sheff. Vanderbilt, New Haven, Conn.

COMING MEETINGS

March–April

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

March 10, monthly meeting, 29 W. 39th St., New York. Secy., R. W. Pope.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION

March 21–23, annual convention, Congress Hotel, Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock.

AMERICAN SOCIETY OF CIVIL ENGINEERS

March 1, 15, bi-monthly meetings, 220 W. 57th St., New York. Secy., C. W. Hunt.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Monthly meetings: March 14, 29 W. 39th St., New York; March 17, Boston, Mass. Spring Meeting, May 30–June 2, Pittsburg, Pa. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN SOCIETY OF RAILROAD SUPERINTENDENTS

March 22, spring meeting, Great Northern Hotel, Chicago, Ill. Secy., O. G. Fetter, Carew Bldg., Cincinnati, O.

BOSTON SOCIETY OF CIVIL ENGINEERS

March 15, annual meeting, Boston City Club, Boston, Mass. Secy., S. Everett Tinkham, 715 Tremont Bldg.

CANADIAN CEMENT AND CONCRETE ASSOCIATION

March 7–9, annual convention, Toronto, Ont., Can. Secy., W. Snath, 57 Adelaide St., E.

CANADIAN MINING INSTITUTE

March 2–4, annual meeting, Quebec, Canada. Secy., H. Mortimer-Lamb, Rms. 3–4 Windsor Hotel, Montreal.

ENGINEERING SOCIETY OF WISCONSIN

March 1–3, annual meeting, Madison, Wis. Secy., W. G. Kirchoffer, Vroman Bldg.

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS

April 12–13, annual meeting, Huntington Hall, Mass. Inst. of Tech., Boston, Mass. Secy., C. J. H. Woodbury, Mem.Am.Soc.M.E., Rm. 501 International Trust Bldg.

NATIONAL METAL TRADES ASSOCIATION

April 12–13, annual convention, Hotel Astor, New York. Comr., Robt. Wuest, New England Bldg., Cleveland, O.

NEW ENGLAND RAILROAD CLUB

March 14, annual meeting, Copley Square Hotel, Boston, Mass. Subject for discussion: Master Car Builders' Rules for Interchange. Secy., Geo. H. Frazer, 10 Oliver St.

NEW ENGLAND STREET RAILWAY CLUB

March 23, annual meeting, Boston, Mass. Secy., John J. Lane, 12 Pearl St.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION

February 28–March 1, annual convention, Minneapolis, Minn. Secy., Harvey B. Smith, 834 Security Bank Bldg.

RAILWAY SIGNAL ASSOCIATION

March 20, Stated Meeting, Congress Hotel, Chicago, Ill. Paper: Alternating Current Signaling. Secy., C. C. Rosenberg, Bethlehem, Pa.

ROME MUNICIPAL GAS COMPANY

April 19–21, annual meeting, Montgomery, Ala. Pres., James Ferrier, Rome, Ga.

TORONTO CEMENT SHOW

March 6–11. Under the auspices of the Canadian Cement and Concrete Association. Secy., W. Snath, 57 Adelaide St., E., Toronto, Ont., Can.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
March			
2	Blue Room Engineering Society	W. D. Sprague	8.15 p.m.
9	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
10	American Institute Electrical Engineers	R. W. Pope	8.15 p.m.
14	American Society Mechanical Engineers	C. W Rice	8.15 p.m.
17	New York Railroad Club	H. D. Vought	8.15 p.m.
21	New York Telephone Society	T. H. Lawrence	8.15 p.m.
22	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
April			
6	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
11	American Society Mechanical Engineers	C. W. Rice	8.15 p.m.
13	Illuminating Engineering Society	P. S. Millar	8.00 p.m.
13	Institute of Operating Engineers	M. W. Rice	8.00 p.m.
14	American Institute Electrical Engineers	R. W. Pope	8.15 p.m.
18	New York Telephone Society	T. H. Lawrence	8.15 p.m.
21	New York Railroad Club	H. D. Vought	8.15 p.m.
24	National Isolated Power Plant Association	E. Fieux	8.00 p.m.
26	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.

CURRENT BOOKS

STEAM TURBINES: THEIR DESIGN AND CONSTRUCTION. By Rankin Kennedy. *New York, The Macmillan Co., 1910.* Cloth 12mo, 104 pp., illustrated. Price $1.25 net.

Contents: Theoretical, Mechanical and Physical; Elementary Turbines; Turbine Wheels in Series; Calculating the Principal Dimensions: The Construction of Turbine Wheels.

AN INTRODUCTION TO THERMODYNAMICS FOR ENGINEERING STUDENTS. By John Mills. *New York, Ginn & Co.* Cloth 8vo., 136 pp.

Contents: Fundamental Concepts and Laws; Gases; Water and its Saturated Vapor; Superheated Steam; Flow of Steam and Gases; Miscellaneous Problems.

HYDRAULIC TURBINES, THEIR DESIGN AND INSTALLATION. By Viktor Gelpke and A. H. Van Cleve. *New York, McGraw-Hill Book Co., 1911.* Cloth 8vo, 293 pp., illustrated. Price $4 net.

Contents: Turbines and their Accessories; Turbine Design; Notable Turbine Installations.

A POCKET BOOK OF MECHANICAL ENGINEERING FOR ENGINEERS AND STUDENTS. By Charles M. Sames. *Jersey City, N. J., Charles M. Sames, 1911.* Morocco, pocket book size, 218 pages.

Contents: Mathematics, Chemical Data; Materials, The Strength of Materials, Structures, and Machine Parts; Energy and the Transmission of Power; Heat and the Steam Engine; Hydraulics and Hydraulic Machinery; Shop Data; Electrotechnics; Appendices.

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John E. Sweet
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Penna. State College, State College, Pa.	November 9	J. P. Jackson	W. E. Heibel	G. M. Forker
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Univ. of Cincinnati, Cincinnati, O.	November 9	J. T. Faig	H. B. Cook	C. J. Malone
Univ. of Wisconsin, Madison, Wis.	November 9	C. C. Thomas	A. MacArthur	A. A. Wegner
Univ. of Missouri, Columbia, Mo.	December 7	H. Wade Hibbard	F. T. Kennedy	Osmer N. Edgar
Univ. of Nebraska, Lincoln, Neb.	December 7	C. R. Richards	W. J. Wholenberg	W. H. Burleigh
	1910			
Univ. of Maine, Orono, Me.	February 8	Arthur C. Jewett	A. H. Blaisdell	W. B. Emerson
Univ. of Arkansas, Fayetteville, Ark.	April 12	B. N. Wilson	W. Q. Williams	H. W. Barton
Yale University, New Haven, Conn.	October 11	L. P. Breckenridge	ClaytonDuBosque	W. Roy Manny
Rensselaer Poly. Inst., Troy, N. Y.	December 9	A. M. Greene, Jr.	G. K. Palsgrove	H. J. Parthesius
	1911			
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Ohio State University, Columbus, O.	January 10	W. T. Magruder	H. A. Shuler	H. M. Bone

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This chasing tool greatly extends the working range of the turret lathe, for it is now possible to include that class of chuck work which was formerly retained by the lathe on account of its having a screw thread.

Much of this work has been distinctly turret lathe work, but on account of the turret lathe having no accurate means of completing all operations, including the screw threading, it has been necessary to have all the work done on the engine lathe.

But now, with this feature the chuck work with screw threads may have the advantage of the most rapid and accurate scheme of screw cutting combined with the unflinching tool control and other features for accurate duplication that may be found in this turret lathe.

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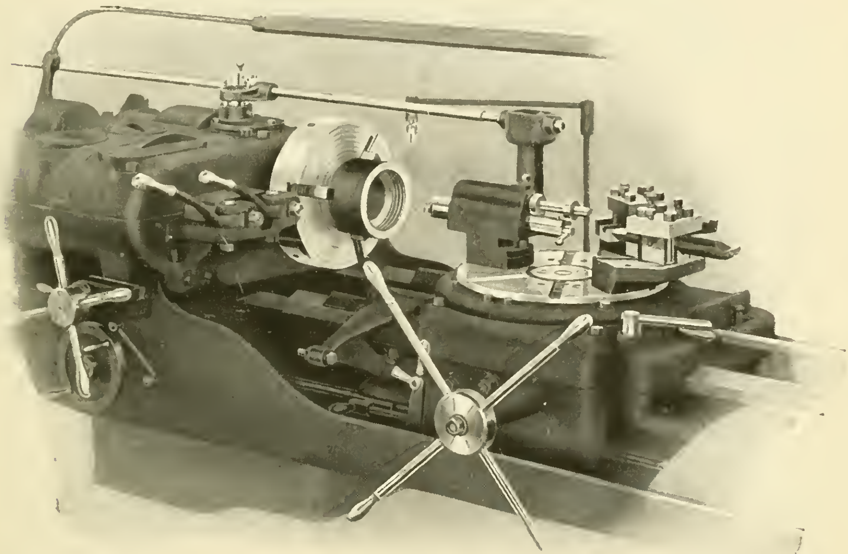

The above cut shows the chasing tool in working operation (some of the other tools have been removed to give a fuller view).

The main casting may be bolted square for parallel screws, or at any angle for taper screws. A removable key fits slot in turret top for holding tool in position for parallel threads.

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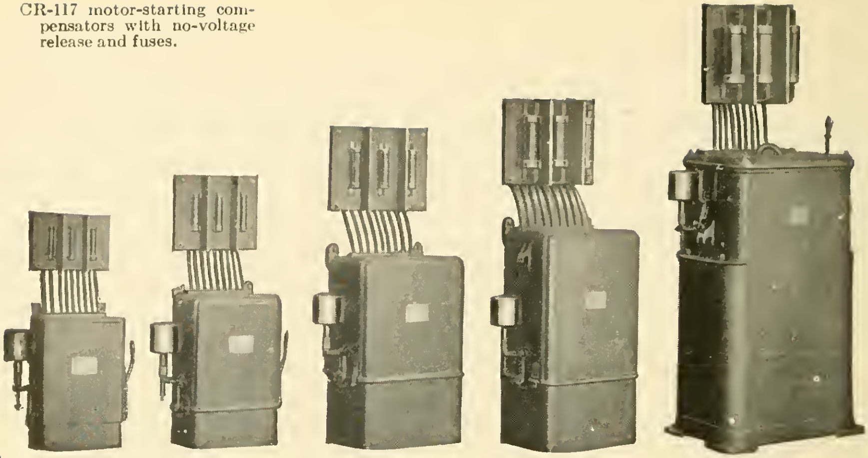

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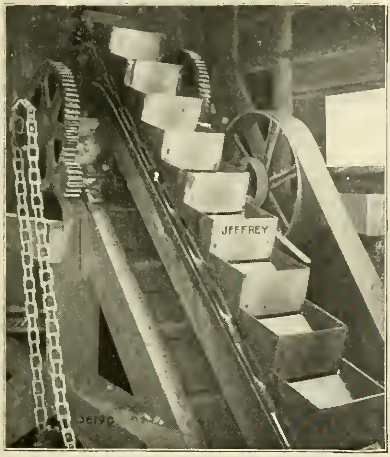

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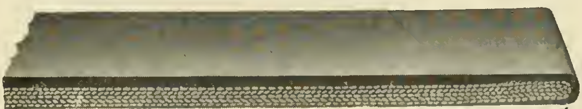

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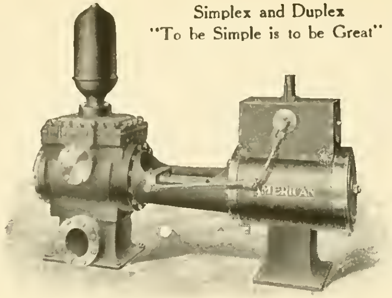

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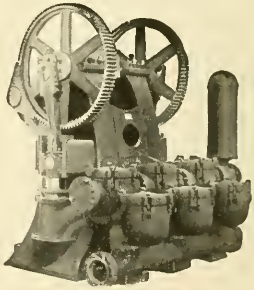

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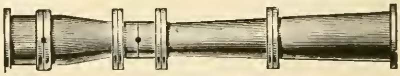

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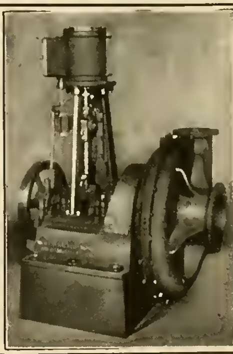

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THE

JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTAINING THE PROCEEDINGS

APRIL 1911

SPRING MEETING, PITTSBURG, MAY 30—JUNE 2.
MONTHLY MEETINGS: NEW YORK, APRIL 11;
BOSTON, APRIL 21; PHILADELPHIA, APRIL 22

APRIL 1911 VOL. 33 No. 4

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OF

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CONTENTS

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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 33 APRIL 1911 NUMBER 4

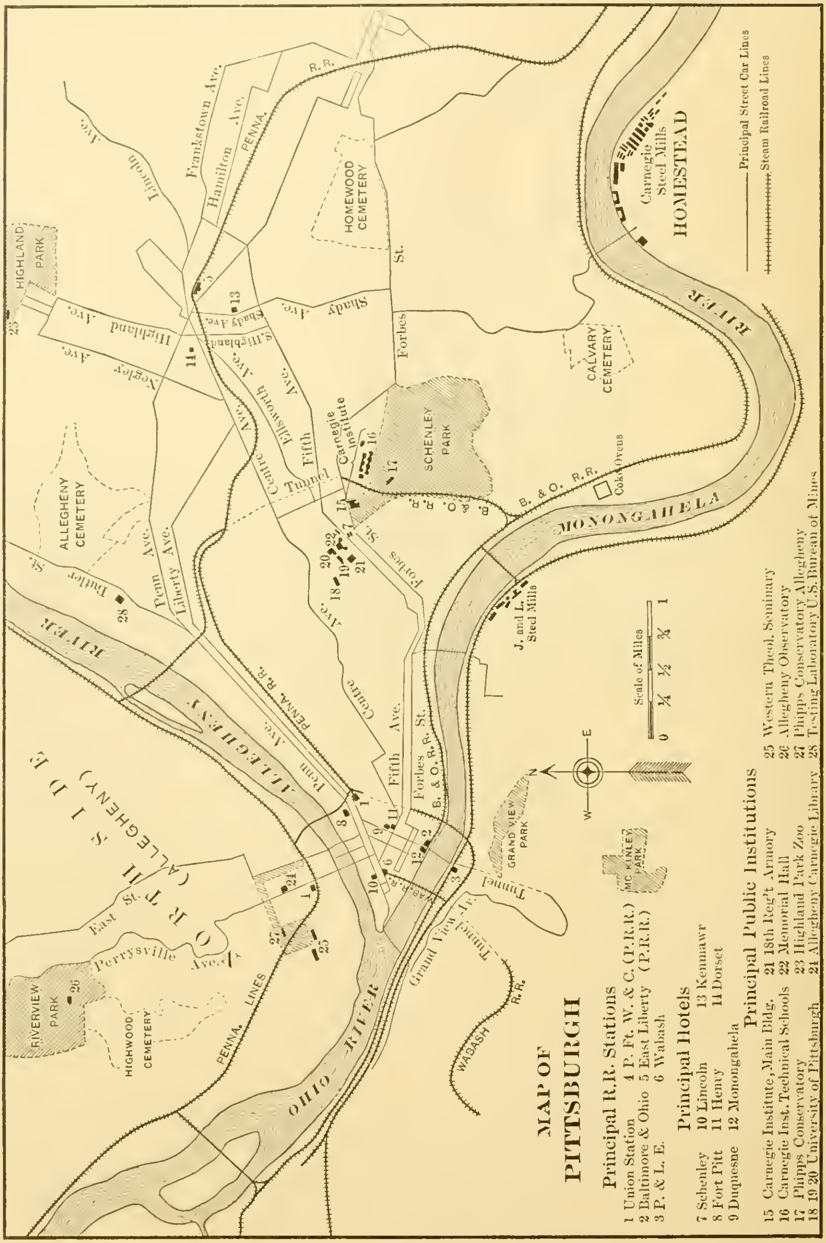
THE SPRING MEETING

Preparations are actively under way for the Spring Meeting to be held at Pittsburg, Pa., May 30 to June 2. The headquarters during the meeting will be at Hotel Schenley and the Society is fortunate in being able to arrange to hold its professional sessions at the Carnegie Institute which is in close proximity to the hotel and most attractive as a meeting place and rendezvous for such an occasion as this. Application for rooms should be made direct to the hotel and not through the local committee.

The Committee on Meetings have provided professional sessions of unusual interest and particularly adapted for an industrial center like Pittsburg. The first session for the presentation of papers will be on Wednesday morning on the subject of The Mechanical Engineering of Cement Manufacture, following which there will be an opportunity to visit the plant of the Universal Portland Cement Company through invitation of its President, E. M. Hagar. The special train to this plant will stop at East Pittsburg giving members an opportunity to visit the Westinghouse works. On Wednesday evening there will be a session on Machine Shop Practice at which the subjects of assembling small machine parts and the development of milling cutters will be discussed.

On Thursday morning the session will be very short with miscellaneous papers, after which an excursion on the river is planned. This will be one of the most delightful features of the entertainment and one in which everybody will wish to participate. In the evening will be the reception and dance.

On Friday morning there will be papers relating to steel works machinery with especial reference to blowing engines and forging


MAP OF PITTSBURGH
Principal R.R. Stations
1 Union Station 4 P. Ft. W. & C. (P.R.R.)
2 Baltimore & Ohio 5 East Liberty (P.R.R.)
3 P. & L. E. 6 Wabash
Principal Hotels
7 Schenley 10 Lincoln 13 Kenmawr
8 Fort Pitt 11 Henry 14 Dorset
9 Duquesne 12 Monongahela
Principal Public Institutions
15 Carnegie Institute, Main Bldg. 21 18th Reg't Armory 25 Western Theol. Seminary
16 Carnegie Inst. Technical Schools 22 Memorial Hall 26 Allegheny Observatory
17 Phipps Conservatory 23 Highland Park Zoo 27 Phipps Conservatory Allegheny
18 19 20 University of Pittsburgh 24 Allegheny Carnegie Library 28 Testing Laboratory U.S. Bureau of Mines
Scale of Miles
0 ¼ ½ ¾ 1
Principal Street Car Lines
Steam Railroad Lines
N
E
W
HOMESTEAD
Carnegie Steel Mills
MONONGAHELA
RIVER
ALLEGHENY
RIVER
OHIO RIVER
NORTH SIDE (ALLEGHENY)
SCHENLEY PARK
HOMEWOOD CEMETERY
CALVARY CEMETERY
ALLEGHENY CEMETERY
HIGHLAND PARK
RIVERVIEW PARK
HIGHWOOD CEMETERY
GRAND VIEW PARK
MC KINLEY PARK
J. and L. Steel Mills
Coke Ovens
Carnegie Institute
B. & O. R.R.
PENNA. R.R.
PENNA. LINES
WABASH R.R.
Frankstown Ave.
Hamilton Ave.
Lincoln Ave.
Highland Ave.
Negley Ave.
Shady Ave.
Forbes St.
Fifth Ave.
Centre Ave.
Ellsworth Ave.
Penn Ave.
Liberty Ave.
Butler St.
East St.
Perrysville Ave.
Grand View Av.
Tunnel

presses. Friday afternoon will close the convention with excursions provided for that afternoon.

A session is also planned for the Gas Power Section, and in view of the fact that Pittsburg is a center of the natural-gas region and that many gas-power plants as well as producer plants have been installed in that vicinity, there will be a large attendance of engineers interested in this subject.

The manufacturers of Pittsburg have very generally extended invitations to their works and the Local Committee, E. M. Herr, Chairman, and E. K. Hiles, Secretary, have under way a program for entertainment which can best be described as one commensurate in every way with the wonderful opportunities of this great center.

Previous to this meeting the American Foundrymen's Association is to convene in Pittsburg and the exhibit of foundry appliances, under the auspices of the association, will be held over during two days of the meeting of The American Society of Mechanical Engineers.

There are many features and points of general interest aside from those connected with the industries which will be taken advantage of in the entertainment provided for the ladies and such members and guests as desire to attend. The International Art Exhibit at the Carnegie Institute will be open at this time, and it is probable an organ recital will be held at the institute.

RAILROAD TRANSPORTATION NOTICE

Arrangements for hotel, transportation and Pullman car accommodations should be made personally.

Special concessions have been secured for members and guests attending the Spring Meeting in Pittsburg, May 30 to June 2, 1910.

The special rate of a fare and three-fifths for the round trip, on the certificate plan, is granted when the regular fare is 75 cents and upwards, from territory specified below.

a Buy your ticket at full fare for the going journey, between May 26 and June 1 inclusive. At the same time request a certificate, *not a receipt*. This ticket and certificate should be secured at least half an hour before the departure of the train.

b Certificates are not kept at all stations. Ask your station agent whether he has certificates and through tickets. If not, he will tell you the nearest station where they can be obtained. Buy a local ticket to that point, and there get your certificate and through ticket.

c On arrival at the meeting, present your certificate to S. Edgar Whitaker, office manager at the Headquarters. A fee of 25 cents will be collected for each certificate validated. No certificate can be validated after June 2.

d An agent of the Trunk Line Association will validate certificates, May 31, June 1, 2. No refund of fare will be made on account of failure to have certificate validated.

e One-hundred certificates and round trip tickets must be presented for validation before the plan is operative. This makes it important to show the return portion of your round trip ticket at Headquarters.

f If certificate is validated, a return ticket to destination can be purchased, up to June 6, on the same route over which the purchaser came, at three-fifths the rate.

The special rate is granted only for the following:

The Trunk Line Association:

All of New York east of a line running from Buffalo to Salamanca, all of Pennsylvania east of the Ohio River, all of New Jersey, Delaware and Maryland; also that portion of West Virginia and Virginia north of a line running through Huntington, Charleston, White Sulphur Springs, Charlottesville, and Washington, D. C.

Hotel Rates for Spring Meeting at Pittsburg

Minimum Rates

	Without Bath			With Bath		
	Single Room	Single Room Two Persons	Double Room Two Persons	Single Room	Single Room Two Persons	Double Room Two Persons
Hotel Schenley	$2.00	$3.00	$—	$3.00	$4.00	$5.00
Fort Pitt Hotel	1.50	—	2.50	2.50	—	3.50
	2.00	—	3.00	5.00		7.00
Hotel Henry	1.50	2.50	3.00	2.50	3.50	4.00
	2.00	up	up	up	up	up
Monongahela House	1.50	—	2.00	2.50	—	4.00
	2.00		3.00	3.00		5.00
Hotel Anderson	1.00	1.50	3.00	2.50	—	4.00
		2.00	4.00	3.50		
Duquesne Hotel	1.50	—	2.50	2.50	—	3.50
Hotel Lincoln	1.50	—	2.00	2.00	—	3.00
	2.50	—	4.00	3.00		5.00
Seventh Avenue Hotel	1.50	2.50	3.00	2.50	4.00	5.00
Colonial Annex Hotel	1.50	2.00	2.50	2.00	3.00	3.50
						5.00
The Dorset	1.00	—	2.00	2.00	—	3.00
Hotel Lorraine*	2.50	—	4.00	3.00	—	5.00
				3.50		6.00

* American plan.

MONTHLY MEETINGS

NEW YORK MEETING, APRIL 11

At a meeting of the Society in New York on April 11, agricultural machinery, and in particular the farm tractor, will be considered in a paper presented by L. W. Ellis, traction plowing specialist of the M. Rumely Company, La Porte, Ind., on the Economic Importance of the Farm Tractor. Mr. Ellis is expected to present his paper in person. Following the paper Dr. Charles E. Lucke, of Columbia University, will give a talk on the mechanical equipment of farm tractors, illustrated by views taken at the Canadian Industrial Exhibition held in Winnipeg, Manitoba, last summer.

BOSTON MEETING, APRIL 21

At the meeting of the Society in Boston on April 21, the Boston Section of the American Institute of Electrical Engineers and the Boston Society of Civil Engineers coöperating, a paper will be presented by B. R. T. Collins, with the Stone and Webster Corporation, Boston, on Oil Fuel for Steam Boilers. The paper deals with the possible use of oil fuel for steam generating purposes in the Atlantic coast states, its safety and permanency of supply, as well as conditions under which it may have special advantages over coal.

PHILADELPHIA MEETING, APRIL 22

A meeting of the Society will be held at the Engineers' Club in Philadelphia, on Saturday evening, April 22, at which the subject for discussion will be The Recent Work of the United States Fuel Testing Plant.

PAST MEETINGS

NEW YORK MEETING, MARCH 10

A meeting of the Society for the consideration of the subject of Industrial Power was held in New York on March 10, in which the American Institute of Electrical Engineers coöperated. Three papers were presented, two by John C. Parker, Mem.Am.Soc.M.E., general manager of the Parker Boiler Company of Philadelphia, Comments on

Fixed Costs in Industrial Power Plants, and Notes on the Cost of Electrical Energy; and a third, The Cost of Industrial Power by A. E. Hibner, Assoc.A.I.E.E., industrial engineer of the Toronto Electric Light Company of Toronto. N. T. Wilcox, Mem.A.I.E.E. and Chairman of the Industrial Power Committee of the institute, presided during the discussion.

Mr. Parker called attention, in the first of his papers, to the importance of capitalizing the cost of supervision and of proper insurance in predetermining the cost of electric power; and in the second gave an account of certain attempts to derive a general equation for the cost of power, without result. The three factors involved in every industrial power problem, namely, investment charges, operating charges, and cost of heating, were treated by Mr. Hibner, who argued that the small power user should take his problems to an independent consulting engineer before deciding whether he should build his own power plant or secure power from a supply company.

The papers were discussed by N. T. Wilcox; P. R. Moses, Mem. A. I. E. E., of New York; D. B. Rushmore, Mem. Am. Soc. M. E., of the General Electric Company, Schenectady, N. Y.; R. P. Bolton, Mem.Am.Soc.M.E., of New York, Arthur Williams, Mem.A.I.E.E., of the New York Edison Company, New York; Parker H. Kemble, Mem.Am.Soc.M.E., of the Edison Illuminating Company of Brooklyn; H. H. Edgerton of New York; C. M. Ripley, Assoc.A.I. E.E., New York; George L. Fowler, Mem.Am.Soc.M.E., of New York. Written discussions were contributed by H. W. Peck, Assoc. Am.Soc.M.E., of the Rochester Railway and Light Company, Rochester, N. Y.; John H. Norris, Mem.Am.Soc.M.E., of the National Meter Company, Brooklyn; R. H. Tillman, Assoc.A.I.E.E., of the Consolidated Gas Electric Light and Power Company of Baltimore; Walter S. Timmis, Mem.Am.Soc.M.E., of New York; Stonewall Tompkins, Mem.Am.Soc.M.E., chief engineer of the Coney Island and Brooklyn Railroad Company of Brooklyn; F. G. Gasche, Assoc.A.I. E.E., mechanical engineer of the Illinois Steel Company of South Chicago; William B. Jackson, Life Member Am.Soc.M.E., of Chicago; and Rudolph Tschentscher, superintendent and electrical engineer of the Illinois Steel Company of South Chicago.

SAN FRANCISCO MEETING, MARCH 10

A meeting of the Society was held in San Francisco, on March 10, which supplemented the meeting of December 16, 1910, at which the

subject of Pacific Coast Practice in the Use of Crude Petroleum was considered in a series of eight papers, covering various phases of the topic. An additional paper, Locomotive Practice in the Use of Fuel Oil, by Howard Stillman, mechanical engineer and engineer of tests with the Southern Pacific Company, was presented, and the meeting thrown open for general discussion. Among those who participated were G. W. Dickie, E. J. Dyer, W. F. Durand of Stanford University, Thomas Morrin, and Messrs, Berry and Yeatman.

BOSTON MEETING, MARCH 17

At a meeting of the Society held in Boston, March 17, the Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers coöperating, a paper on Speed Regulations in Hydro-Electric Plants by W. F. Uhl was presented. This paper deals with the inefficiency of well designed governors on turbine units to obtain satisfactory speed regulation and gives formulae and tables for calculating it on open-flame and encased turbines. It was discussed by W. G. Starkweather, Mem.Am.Soc.M.E., of the Wheeler Condenser Co., R. S. Hale, Mem.Am.Soc.M.E., of the Essex Water Power Co., H. E. Lawrence of the Lombard Governor Co., F. M. Gunby, J. W. Cooke of the Electric Storage Battery Company, T. S. Bedford of the Electric Storage Battery Company, F. N. Connett, of the Builders Iron Foundry Co., E. A. Ekern of the Stone and Webster Engineering Corporation.

CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT

The first division of a collection of Condensed Catalogues of Mechanical Equipment is published in this issue of The Journal. The purpose of the Condensed Catalogues is to furnish a concise statement of the salient features of the product of manufacturers of mechanical equipment, the statement comprising a condensation from manufacturers' catalogues of such facts as are most likely to be required by engineers and machinery users for purposes of preliminary reference; as for instance, tables of dimensions, sizes and capacities, brief mention of distinctive features and special adaptations.

For convenience of reference the Condensed Catalogues are being published in trade divisions, commencing with Power Plant Equipment in this issue. Other divisions to be included in subsequent

issues are Hoisting and Conveying Machinery; Power Transmission; Machine Shop and Foundry Equipment; Pumping Machinery, Mining and Metallurgical Equipment; Rolling Mill Equipment; Heating and Ventilating Apparatus; Refrigerating Machinery.

It is desired to make this feature of The Journal a helpful adjunct to the working library of engineers and machinery users; and suggestions in regard to possible improvement of the form and matter of the catalogue pages are invited. It is believed that in undertaking the publication of this collection of standardized catalogue data The American Society of Mechanical Engineers is rendering a service to its membership and to the engineering profession as a whole.

STUDENT BRANCHES

ARMOUR INSTITUTE

The Armour Institute Student Branch held a regular meeting, March 22, at which Paul M. Bird, Mem. Am. Soc.M.E., read a paper on The Prevention of Smoke.

BROOKLYN POLYTECHNIC INSTITUTE

On March 4 at a meeting of the Polytechnic Institute Student Branch, Vinton Smith gave an interesting lecture on Efficiency-Engineering, following the business of the evening. On the afternoon of March 4 an excursion was made to the Thompson Lovelace Aeroplane Factory with 27 in attendance.

COLUMBIA UNIVERSITY

At a meeting of the Columbia Umiversity Student Branch on February 15, Edwin H. White delivered a lecture on The Art of Welding and Cutting Metals by Means of the Oxy-Acetylene Blow-Pipe, and illustrated his talk with practical use of the blow-pipe. On March 3 a meeting of the Executive Committee was held at which plans for future meetings of the branch were discussed.

CORNELL UNIVERSITY

On February 15 Prof. R. C. Carpenter, Mem.Am.Soc.M.E., outlined in a paper to the Student Branch of Cornell University the history of The American Society of Mechanical Engineers, its organization, aims, etc., and its relation to its student members.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Student Branch of the Massachusetts Institute of Technology held its annual meeting at the Boston City Club, March 14, 1911. The result of the election of officers was as follows: J. A. Noyes, Chair-

man, R. B. Brownlee, Vice-Chairman, R. M. Ferry, Secretary, A. F. Kenrick, Treasurer, and D. H. Carpenter, E. W. DeWitte and L. L. Custer, Governing Committee. The guests and speakers of the evening were Gaetano Lanza, Honorary Chairman of the Student Branch, Calvin W. Rice, Secretary of the Society, Dugald C. Jackson, President A.I.E.E., and members of the Committee on Meetings of the Society in Boston. In brief the speakers pointed out the benefits to be derived from taking an active part in Society affairs by presenting papers and participating in the discussion of others read before its meetings. This would give the student a training he would find invaluable in later life. Coöperative meetings with a view to broadening ones training were also strongly emphasized.

At the meeting, March 7, Henry Cave spoke on the subject of Oxy-Acetelene Welding and Cutting of Metals. Mr. Cave's talk was illustrated by a large number of lantern slides and was concluded with a practical demonstration of the process. The civil, electrical and mining student societies were invited to attend the meeting, bringing the attendance up to 140.

MISSOURI UNIVERSITY

On March 5 at a meeting of the Missouri University Student Branch, The Economic Importance of the Farm Tractor by L. W. Ellis was presented by F. T. Kennedy. This was followed by discussion by Prof. H. W. Hibbard, Prof. E. A. Fessenden and Messrs. Wharton, Staph and Westcott.

OHIO STATE UNIVERSITY

On February 18 the newly organized Ohio State University Student Branch met at the home of Professor Magruder to act on a report of the Committee on Constitution and By-Laws. Nineteen student members were present and also Professors Hitchcock, Judd and Sanborn and H. H. Bailey. After the business of the meeting Professor Magruder gave an historical account of the Society and urged that the members of the Student Branch affiliate themselves with the Society as Juniors after graduation.

The regular monthly meeting was held February 28 when a paper on the Humphrey Gas Pump was read by E. F. Biggert which was followed by an open discussion. Professor Hitchcock gave an interesting account of the leading technical schools of the Middle West and said that the mechanical engineering laboratory of the Ohio State

University compared favorably with any of them. L. E. Allen and I. H. Pohlman were announced as speakers for the next meeting.

PURDUE UNIVERSITY

At a meeting of the Purdue University Student Branch, February 23, Prof. G. A. Young, Mem.Am.Soc.M.E., read a paper on The Story of a Self-Igniting Engine. The subject covered the experience of Professor Young in testing and obtaining the patent of a new self-igniting gas engine.

At the meeting of the Student Branch on March 8, O. H. Day, Purdue, 1909, of the Rumley Tractor Company, La Porte, Ind., read a paper on The Application of the Internal-Combustion Engine to Farm Tractors.

STANFORD UNIVERSITY

On March 1 at a meeting of the Stanford University Student Branch, Mr. Percy of San Francisco, a representative of the Standard Oil Co., gave an illustrated talk on Oil Burning and Burners.

STEVENS INSTITUTE OF TECHNOLOGY

On February 27 at a meeting of the Stevens Institute of Technology Student Branch, a paper by Herbert Agnes on Hydro-Electric Power Plants was read. The paper was introduced by a general consideration of the present development in this field and possible future sources of power as indicated in the report of the U. S. Geological Survey. The various elements that go to make up this class of engineering and the various difficulties to be encountered were also described. Several slides were introduced showing the locations of the various plants, views of some of them, the turbines, generators, etc. The success and the limitations together with an analysis of the costs of generating hydro-electric power were touched upon. Mr. Bauhan, who discussed the paper, described in great detail the various methods and devices for securing continuous services.

At the March 16 meeting a paper on Railway Signals in American Practice by Arthur F. Requa was presented and illustrated with lantern slides. The topics treated in the paper were the direct-current systems as applied to steam roads and the alternating systems as applied to direct-current and alternating-current electric roads. In conclusion views of signaling apparatus were shown and fully explained.

UNIVERSITY OF ARKANSAS

At a meeting of the University of Arkansas Student Branch Prof. B. Mitchel presented a description of the Allis-Chalmers factory at New Allis, and W. B. Gardner read a paper on the Raising of the Maine.

UNIVERSITY OF CINCINNATI

On February 24 a paper on Radial Drills was read by H. M. Morris, Mem.Am.Soc.M.E., before the University of Cincinnati Student Branch.

UNIVERSITY OF ILLINOIS

On March 3 at a meeting of the University of Illinois Student Branch, F. N. Keown discussed the paper by John Calder on The Mechanical Engineer and Prevention of Accidents which was followed by a general discussion by the members.

UNIVERSITY OF WISCONSIN

At a meeting for the election of officers held on February 28 by the University of Wisconsin Student Branch the following were elected: Honorary Chairman, Prof. H. J. B. Thorkelson; President, F. B. Sheriff; Vice-President, George Dorr; Secretary, L. F. Garlock, Assistant Secretary, J. E. Fuller and Treasurer, R. L. Larsen.

YALE UNIVERSITY

At the meeting of the Yale University Student Branch held February 14, Frederick A. Waldron, Mem.Am.Soc.M.E., gave a general discussion of the advantages of modern shop methods, showing how the separation of the departments under individual foremen tends to increase the efficiency of plants formerly operated under the superintendent system. Plans were discussed for taking trips of inspection to well known plants in near-by towns. At the meeting held on March 8, W. S. Murray, chief engineer of the electrification of the New York. New Haven and Hartford Railroad, gave an illustrated talk explaining the construction and operative details of that system, after which the usual informal discussion among the members of the branch was held.

MEETING OF THE COUNCIL

A meeting of the Council was held on March 10, in the rooms of the Society. There were present: E. D. Meier, President, presiding, Stanley G. Flagg, Jr., H. L. Gantt, James Hartness, Alex. C. Humphreys, F. R. Hutton, E. B. Katte, I. E. Moultrop, Jesse M. Smith, H. H. Vaughan, R. M. Dixon, and the Secretary. Regrets were received from Geo. M. Brill, D. F. Crawford, E. M. Herr, W. F. M. Goss and Wm. H. Wiley.

Voted: To rescind R 4.

The Secretary read the report of the Membership Committee with names of approved candidates under the grades suggested.

Voted: That the records of such candidates together with additional names to be approved by the Executive Committee be posted in the Professional Record Sheet to be issued in March and sent to the voting membership in advance of the regular ballot.

Voted: To accept the resignation of Gregory C. Kelley from membership.

The Secretary reported the deaths of the following members: W. H. Corbett, S. E. Freeman, Wm. B. Mason.

Voted: That the resignation of J. Sellers Bancroft as Manager be accepted with regret.

Voted: That the Secretary cast one ballot electing H. G. Stott, as the unanimous choice of the Council to fill the unexpired term of Mr. Bancroft under the provision of C 29.

Professor Hutton presented the report of the Committee on Constitution and By-Laws.

Voted: On recommendation of the Committee on Student Branches, to approve the formation of a Student Branch at Washington University, St. Louis, Mo.

The minutes of the Council meetings of January 10 and February 14 were approved.

The meeting adjourned.

NECROLOGY

CHARLES WALLACE HUNT, PAST-PRESIDENT AM.SOC.M.E.

The death of Charles Wallace Hunt, Past-President of the Society, on March 27, 1911, is announced. An account of his life will appear in an early issue of The Journal.

WILLIAM B. MASON

William B. Mason was born at Durham, Me., December 22, 1852, and died at his home, Dorchester, Mass., February 4, 1911. He received a common school education and first went to work in a machine shop at Biddeford, Me. He later came to Boston and was employed at the Hinckley Locomotive Works and as engineer on various harbor steamers. Mr. Mason then joined the navy as machinist and was assigned to the U. S. S. Omaha. He served for two years on the Pacific Station off the west coast of South America. Returning to Boston he accepted a position with Cressey and Noyes and while there invented the Mason steam pump speed governor, which is today the standard method of control of direct-acting steam pumps. In 1882 the Mason Regulator Company was organized to manufacture the instrument. When this enterprise was well under way Mr. Mason turned his attention to the design of a pump pressure regulator for controlling the discharge pressure on steam driven pumps. He later adapted the same principle to a reducing valve of which many thousands have been made for use under a great variety of conditions. When steam heating was adopted for use on railroad cars the Mason reducing valve was found to be the only one that could be satisfactorily employed and the leading railroad systems of this country, Great Britain and continental Europe have made it their standard. The business was broadened by numerous other devices for controlling steam, water and air at all pressures. When the manufacture of steam automobiles was first attempted by the Stanley Motor Carriage Company, Mr. Mason designed their engine and afterwards manufactured several thousand for the various steam carriage manufacturers.

He was a member of the New England Railroad club.

JOHN O. NORBOM

John O. Norbom was born at Fredrikssbad, Norway, September 12, 1865. He was graduated from the Horton Technical School, Horton navy yard, Norway, in 1883 with the degree of M.E., and for two years worked as draftsman at Fredrikssbad Mekaniske Verksted, Norway. Mr. Norbom then came to this country and was employed at the Risdon Iron Works, San Francisco, Cal., as engineer in the mining department. In 1895 he accepted a similar position with the J. Hendy Iron Works and two years later became manager of the mining department of the British Columbia Iron Works, Vancouver, B. C. He next held the position of mechanical engineer in the mining department of the Union Iron Works, San Francisco. From 1901 to 1903 he was consulting engineer at the East Rand Proprietary Mines, Johannesburg, Transvaal. After the Boer War he returned to his native country, where he examined mines for a London mining syndicate. In 1908 he resumed his work in California as mining engineer.

Mr. Norbom met his death by an accidental explosion on a ferry-boat on the Bay of San Francisco, January 13, 1911. He was a member of the American Institute of Mining Engineers and the Polytechnical Society of Norway.

THE EDISON ROLL CRUSHERS

By W. H. Mason

ABSTRACT OF PAPER

The causes leading to the design of the Edison crushing rolls are outlined and a comparison is made of the energy of coal as compared with that of dynamite in breaking up stone in the quarry. A description is given of the method of quarrying now employed in conjunction with Edison roll crushers. These rolls store up kinetic energy for use in crushing and sledging large stones and a comparison is made in this connection of rolls of various sizes. The power required for crushing by this method is shown by tachometer records, from which speed, energy and horsepower curves are plotted. Records are given covering a period of two years of the time lost and the cost of repairs on the crushing plant at the Edison Portland Cement Company. Comparisons are made between the theoretical capacity of these rolls and the actual capacity as shown by tests. Both of these are enormously greater than for the gyratory crushers and in addition, the larger size of the stones which can be handled by the rolls greatly simplifies and cheapens the quarrying operation. A description is given of the crushing plant of the Tomkins Cove Stone Company which has a capacity of 1000 tons an hour.

THE EDISON ROLL CRUSHERS

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The rapid growth of concrete construction in this country is causing unusual interest in the manufacture of cement, most of which is made from broken stone which also constitutes about two-thirds of the bulk of ordinary concrete. This paper discusses the Edison method of quarrying and crushing stone, both for the manufacture of cement and for concrete, railroad ballast, macadam, etc.

2 Some years ago, Thomas A. Edison experimented with the concentration of a very lean magnetic iron ore at Edison, N. J., employing the usual plant for crushing stone, which consisted of several jaw crushers. The stone in the quarry was drilled with a close spacing of drilled holes, and after being blasted was broken up by hand sledging into pieces of approximately 100 lb. in size. This caused a large expenditure for drilling, dynamite, hand sledging and hand loading. Mr. Edison soon realized that in concentrating this lean iron ore commercially it was necessary to reduce the cost of quarrying and crushing to a much lower point than had been realized heretofore in operations of a similar character, for in order to produce one ton of concentrates it was necessary to quarry, crush and treat about four tons of the lean ore.

3 In approaching this problem, Mr. Edison reasoned "the total heat or energy in 1 lb. of pea coal is approximately 12,500 heat units, but only about 15 per cent of this, or 1875 B.t.u., is available in mechanical energy through the medium of boilers and steam engines, while the available B.t.u. in 1 lb. of nitro-glycerine is approximately 3650. Therefore, in 50 per cent dynamite there is available 1825 B.t.u. per lb. or the same mechanical power that can be derived from 1 lb. of coal. But 1 ton of pea coal is worth approximately $2.50, while 1 ton of dynamite is worth about $250, making

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the commercial advantage of the coal over the dynamite approximately 100 to 1."

4 Realizing also that a large part of the dynamite used in ordinary quarrying operations was expended not so much in breaking out the stone from the ledges in the quarry, but in reducing this stone to such sizes as could be handled in the crushers, he set out to design a crusher capable of taking much larger stone. He first constructed a pair of rolls 5 ft. long and 6 ft. in diameter having small protuberances on the surfaces, as shown in Fig. 1. This would take and crush larger pieces than the jaw crushers then in use, but if a stone were fed to the rolls greater than the angle of grip of the rolls, it would ride on top and rapidly wear down the knobs on the plates or tear the plates from the surface of the rolls.

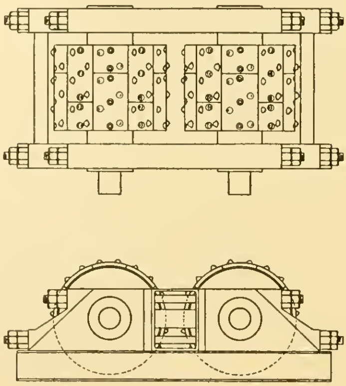

Fig. 1 Original Rolls Patented in 1895

5 Mr. Edison then invented the slugger, consisting of two rows of high knobs on one roll set diametrically opposite (Fig. 2). These knobs were put on with the idea of mechanically slugging the larger stones to such a size as to come within the angle of grip of the rolls. He had found that the rolls would frequently stop on receipt of a large charge of stone, not having sufficient power to crush the rock. To remedy this he ran the rolls at a much higher speed than when they were first erected, storing up sufficient kinetic energy to perform the actual crushing operation. This increase of speed accomplished two purposes: it increased the kinetic energy and delivered a much harder blow from the slugging knobs.

6 When the rolls receive a stone larger than they can grip, it tends to ride on top of the rolls, but the slugger prevents this, since it delivers 440 blows per minute and the stone must rise two or more inches in approximately $\frac{1}{24}$ of a second or be shattered.

7 The rolls were designed primarily to reduce the expense of quarrying, which is usually much larger than the crushing costs, whatever type of crusher is used. In order to do this, it was necessary to set the drilled holes far apart and to blow out the stone or ore in large pieces, thus making a great saving in both drilling and blasting. Mr. Edison also had especially constructed two steam shovels, much heavier than any previously built and special cars to load, transport and dump these large pieces of stone into the rolls. With this combination it was possible to reduce the cost of quarrying and crushing to about one-fourth of what it had been when using the jaw crushers. About the time these improvements in quarrying and crushing were made, the development of the Mesaba iron ore deposits caused such a reduction in the price of iron ore that the Edison plant, with its extremely low-grade ore was unable to compete.

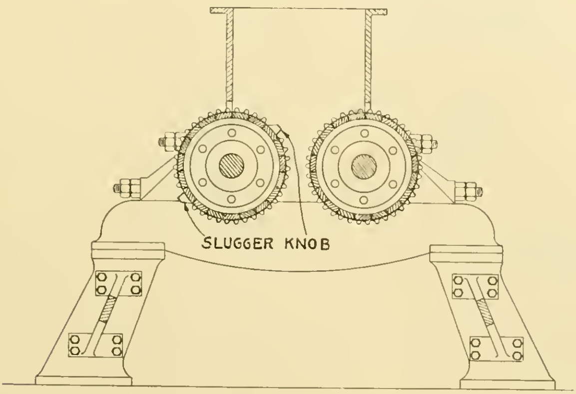

Fig. 2 Original Rolls with Sluggers added

8 Having developed these crushing rolls and much other machinery for handling and milling ore or stone, Mr. Edison subsequently projected the Edison Portland Cement Company and there installed the set of 5 ft. by 5 ft. rolls shown in Figs. 3 and 4. These views show the

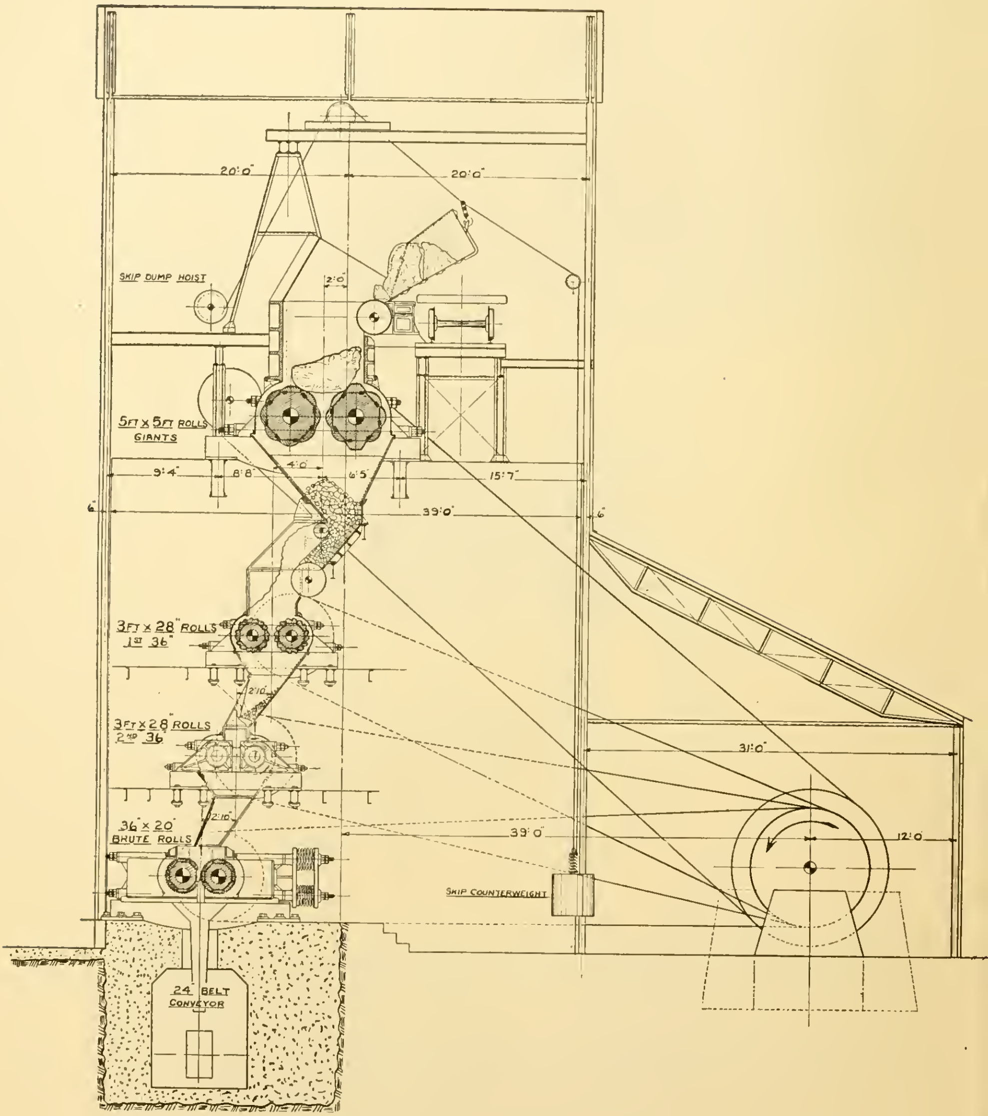

FIG. 3 SECTIONAL VIEW OF THE CRUSHING PLANT OF THE EDISON PORTLAND CEMENT COMPANY

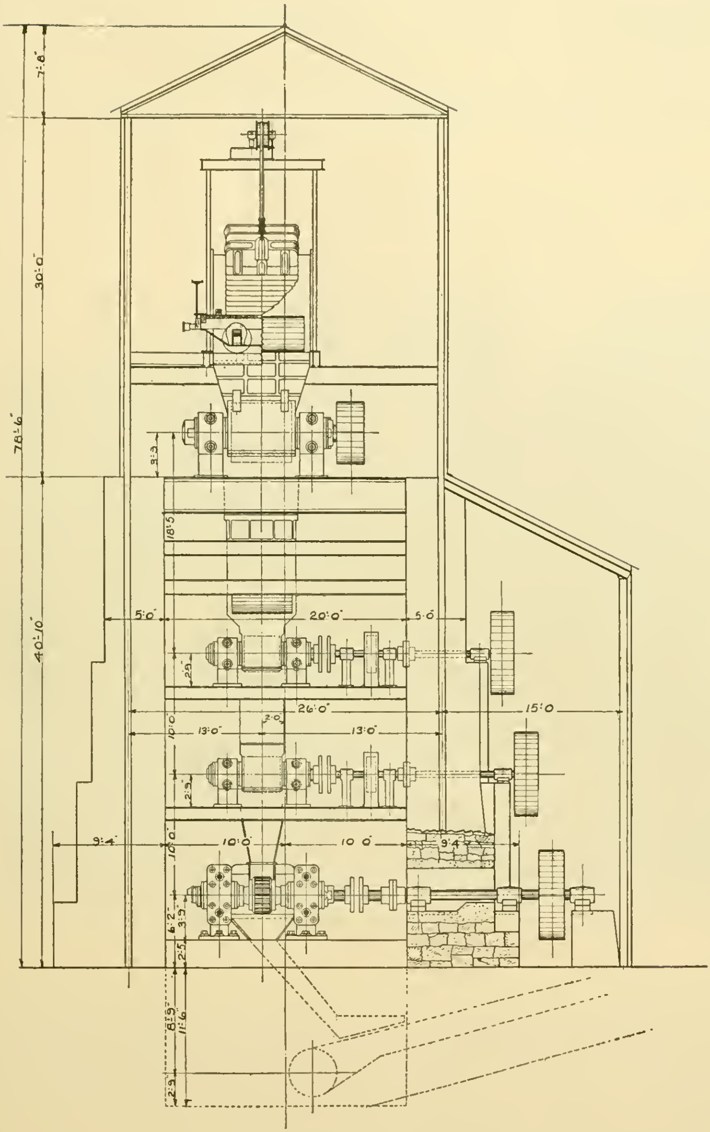

FIG. 4 END ELEVATION OF THE CRUSHING PLANT OF THE EDISON PORTLAND CEMENT COMPANY

general arrangement of the crusher house, containing 4 sets of rolls, which reduce the stone successively from pieces weighing 8 to 10 tons to $\frac{1}{2}$-in. chips. This crushing plant has been in operation for 8 years.

9 Before Mr. Edison constructed his giant rolls, the largest rolls in use were those known as the Cornish rolls, which were geared

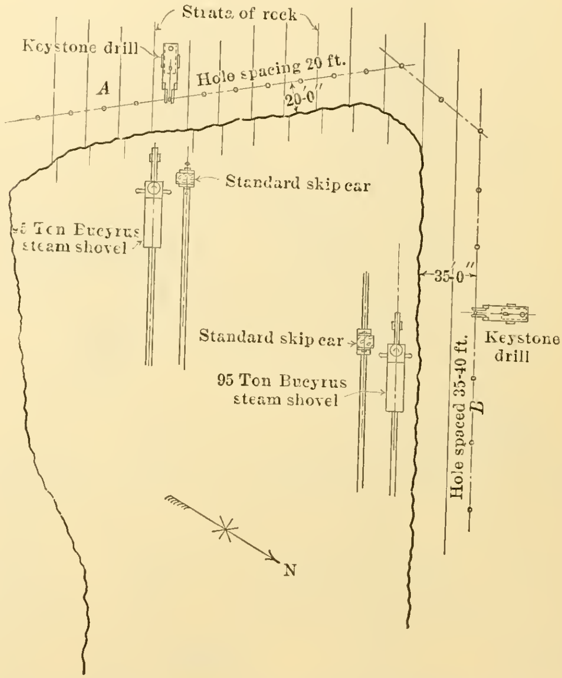

Fig. 5 Diagram of Cement Stone Quarry

together. The kinetic energy of a pair of these rolls, 16 in. in face, 30 in. in diameter and 100 r.p.m., is 8100 ft-lb. The kinetic energy of a pair of 5 ft. by 5 ft. Edison, 220 r.p.m. rolls is 2,280,000 ft-lb. The kinetic energy of a pair of Edison rolls, 6 ft. in. diameter 7 ft. long at 175 r.p.m., is 4,217,000 ft-lb. The largest gyratory crusher that the writer knows of has a 42-in. opening; that is, it will take a stone something less than a 42-in. cube, while the Edison 6 ft. by 7 ft. giant rolls will take a stone about 7 ft. cube. The 42-in. cubic stone weighs

approximately $3\frac{1}{2}$ tons, while a 7-ft. cube weighs approximately 28 tons, which is probably larger than can be handled economically by the largest steam shovels now manufactured. It is an ordinary occurrence, however, to crush a stone weighing over 15 tons.

10 The cement stone quarry of the Edison cement plant is an open cut with the strata running vertically or approximately so. The stone rises from 60 ft. to 80 ft. above the floor of the quarry, with a 3-ft. or 4-ft. layer of clay on top, which is removed by a small revolv-

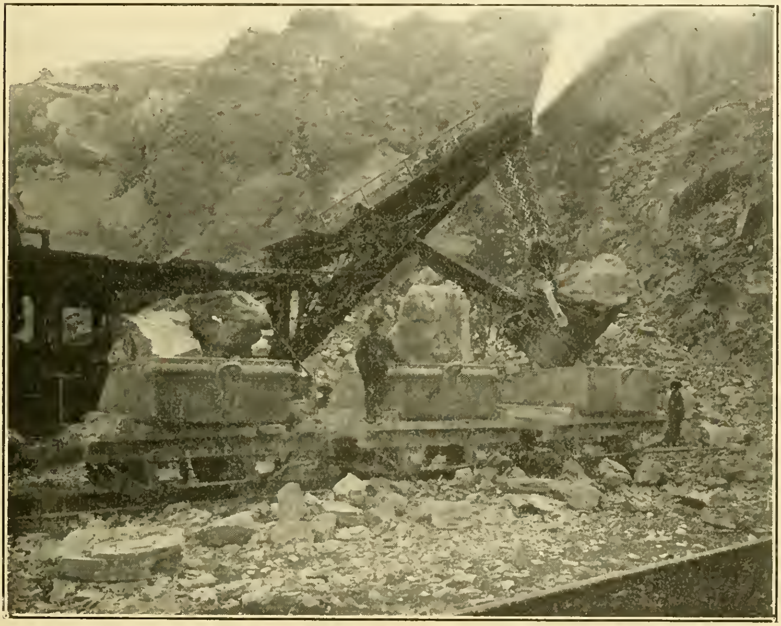

Fig. 6 Steam Shovel Loading Large Stones

ing steam shovel and loaded into carts. Holes are drilled with a churn drill from the top of the quarry to about 6 ft. below the floor. These holes are 6 in. in diameter and about 20 ft. apart and set back about 20 ft. from the face of the quarry, which is worked on two sides, at *A* and at *B*. On account of the stratification, indicated in Fig. 5, it has been found necessary to use more dynamite when working face *A* than when working face *B*. While working *B* the holes can be spaced at least twice as far apart when using the same amount of dynamite in each hole as in those on face *A*. When a hole is drilled

it is usually squibbed in the bottom by putting 30 to 50 lb. of dynamite in the bottom of the hole and exploding it. This enlarges the bottom of the hole, making room for more powder at this point. Then the holes are loaded with 50 per cent dynamite, which fills up the portion which has been squibbed and runs up to about the level of the quarry floor. From this point to within 30 ft. from the top of the quarry the hole is loaded with 30 per cent dynamite. The remainder is tamped only, no powder being needed, since the explosion will shear off the top 30 ft. From 400 to 800 lb. of dynamite is put into each hole, and is then detonated by connecting the electric exploders to a 500-volt circuit from the power plant. The usual blast is from 6 to 14 holes. In some blasts we have broken down 60,000 tons of stone at one time.

TABLE 1 SIZES OF ROCK GRIPPED AND PASSED BY 6 FT. BY 7 FT. ROLLS FOR DIFFERENT SPACING OF ROLLS

Center to Center of Rolls		Bottom to Bottom of Corrugations	Size of Maximum Gripped	Maximum Cube Gripped	Maximum Cube Gripped	Maximum Stone Gripped at 165 Lb. per Cu. Ft.	Ratio of Cubes Gripped	Maximum Cube through Rolls	Maximum Cube through Rolls	Maximum Stone through Rolls at 165 Lb. per Cu. Ft.	Crushing Ratio
Ft.	In.	In.	In.	Cu. In.	Cu. Ft.	Tons		Cu. In.	Cu. Ft.	Tons	
6	2	6	6	13824	8.00	0.66	1.00	75	0.043	0.0035	38.0
6	5	9	27	19682	11.40	0.94	1.42	262	0.15	0.012	16.3
6	8	12	30	27000	17.80	1.46	1.95	614	0.36	0.030	9.2
6	11	15	33	35937	20.80	1.72	2.60	1331	0.77	0.064	5.6
7	2	18	36	46656	27.00	2.22	3.35	2744	1.58	0.130	3.5
7	5	21	39	59319	34.20	2.82	4.28	4913	2.85	0.235	2.5
7	8	24	42	74088	42.75	3.53	5.35	8000	4.63	0.383	1.9
7	11	27	45	91125	52.50	4.33	6.60	12167	7.00	0.580	1.6
8	2	30	48	110592	64.00	5.28	8.00	17576	10.15	0.840	1.3
8	5	33	51	132651	76.50	6.31	9.60	24389	14.00	1.150	1.15
8	8	36	54	157464	91.00	7.50	11.30	32768	19.00	1.560	1.0

11 Ninety-five-ton steam shovels are used to load this stone into special steel skips for transportation to the crushing plant (Fig. 6.) In loading stones of this kind, it is necessary to handle them on the teeth of the steam shovel dipper and to roll them off into the skip. Steam shovel engineers become very adept in doing this, frequently loading a 5 or 8-ton stone in 20 seconds. The train of stone is then delivered to the foot of the incline at the crusher and is pulled up, three cars at a time, by an electric hoist. The skip is loose on the car and is dumped by another electric hoist, as shown in Fig. 3. The entire contents of the car slides into the hopper over the giant rolls.

Two distinct actions take place here: first, the sledging action due to the rapid blows (440 per minute) of the slugging knobs in striking the pieces of stone too large to be caught by the angle of grip of the rolls; second, the rolling action as the pieces are sledged off and caught between the rolls. It requires ordinarily from 5 to 20 seconds to reduce to 6-in. sizes a stone weighing 6 or 8 tons.

12 The delivery of energy is so great in crushing stones of such sizes in so short a time that the rolls at once slow down in speed. The writer has made a number of tachometer tests (Figs. 7 and 8) showing the action of these rolls while crushing a stone. To make these tests, two special Shaeffer and Budenberg recording tachometers constructed with their dials geared together, so they revolved in unison, were used. The recording arms of the tachometers were connected

TABLE 2 MINUTES LOST ON ROLL CRUSHER

	Giant	1st 36 in.	2d 36 in.	3d 36 in.
Belt	2585	72	203	426
Choked	....	383	532	802
Large stone caught in hopper	955	....	....	....
Gears	....	1872	300	....
Starting	44	......	....	....
Bearings	168	282	....	20
Bolts	....	95	....	317
Plates	699	91	....	260
Shafts	337	....	238	....
Chain wobble	....	417	634	....
Sheared	....	1361	150	518
Miscellaneous	311	187	....	....
Total minutes lost	5099	4760	2057	2343
Total hours lost	85	79	34	39
Per cent ran	98½	98¼	99¾	99½

one to each roll-shaft and the dials were revolved while the rolls were crushing the rock. By this means the speed of one roll with relation to the other could be determined at any instant. The tachometer chart (Fig. 7) shows that the slugger roll dropped in speed from 222 r.p.m. to 135 r.p.m. while crushing an 8-ton stone, and the regular roll (Fig. 8) dropped from 220 r.p.m. to 150 r.p.m., when they slowly regained speed until they reached normal.

13 While the second rock, almost as large as the first, was being crushed, the drop in speed was very much less. This may have been due to the fact that the stone was already partly shattered by dyna-

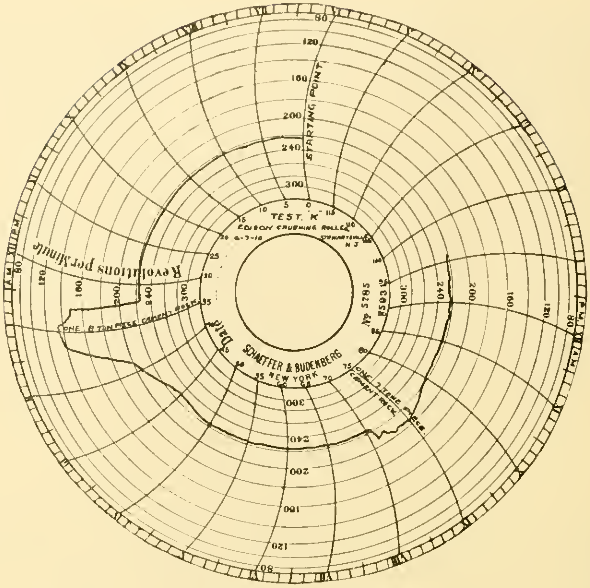

FIG. 7 TACHOMETER CHART FOR SLUGGER ROLL

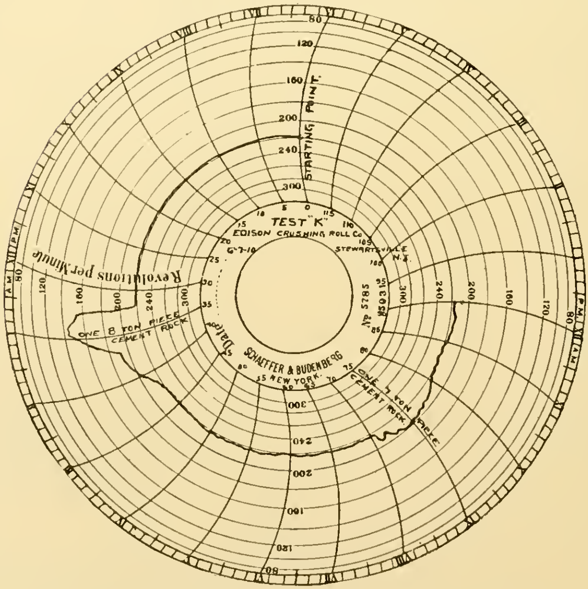

FIG 8 TACHOMETER CHART FOR REGULAR ROLL

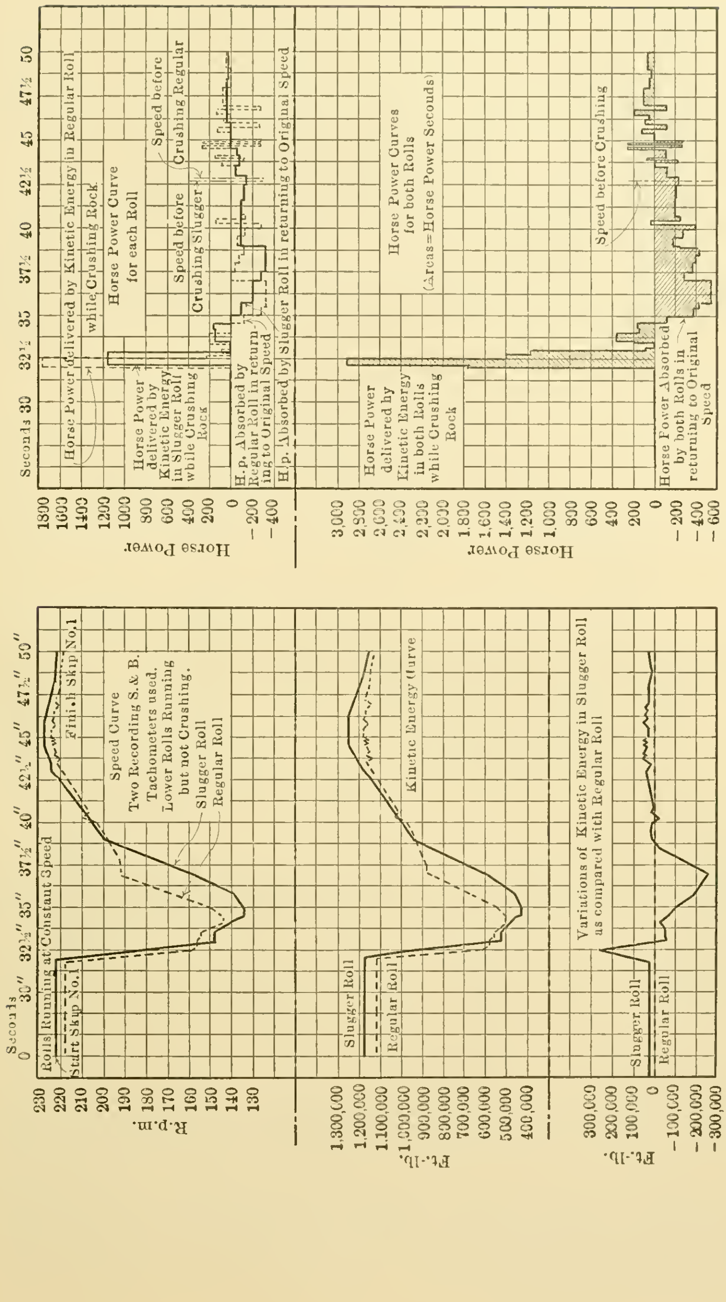

Fig. 9 Curves Plotted from Tachometer Charts

mite, or to the manner in which it struck the roll. In the latter case the slugger roll ran constantly at a higher speed than the regular roll.

14 Fig. 9 is a chart plotted from the dial records on the first stone crushed, showing the reduction in speed of the two rolls at any instant. From this chart was plotted the kinetic energy curve for each roll, the weight of each being about 25 tons. The variation in kinetic energy is also shown for the slugger roll as compared with the regular roll during this crushing operation. From these curves were plotted the horsepower curve, showing the horsepower delivered by the kinetic energy of each roll while crushing this stone, and also the horsepower absorbed by the rolls in returning to the original speed. In the

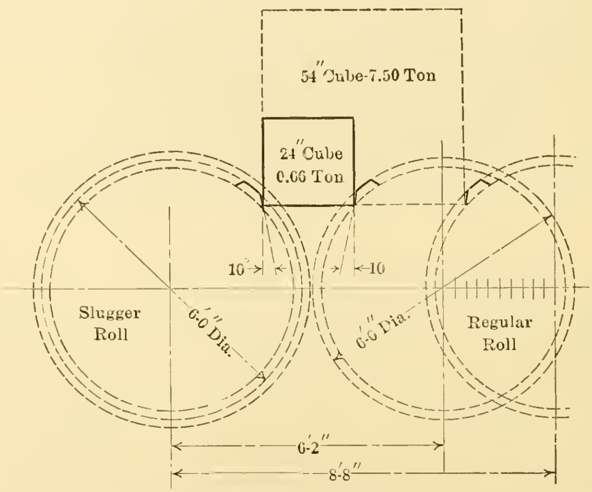

Fig. 10 Diagram of Crushing Rolls Showing Angle of Grip

last diagram on the sheet, by combining the above curves, the horsepower delivered by the kinetic energy of both rolls while crushing rock is shown, also that absorbed by both rolls while returning to their original speed. This shows that for approximately half a second the two rolls delivered 2900 h.p. in kinetic energy, and the engine supplied about 600 h.p. additional, making a total of 3500 h.p. to crush the stone.

15 It can readily be seen how necessary it is to use the kinetic energy of the rolls when crushing rock, as the rated horsepower of the engine which drives these rolls and the three sets of smaller rolls is only 500 h.p. It also shows that practically all the stone was crushed within 3 seconds, while it required about 10 seconds for the rolls to regain their original speed.

16 This reduction in the speed of the rolls occurs through the slipping of the drive belt over the pulleys. The engine slows down somewhat, but only a small amount compared to the slippage. As this slippage occurs only for a short time it causes no serious trouble.

17 The slugger roll does the most work in crushing the stone and should show uniformly a greater reduction in speed than the regular roll. This, however, is not the case, since the action of the stone in passing between the rolls tends to gear the rolls together or to absorb energy from the faster roll and to deliver it to the slower roll.

18 The angle of grip of the rolls is not a definite angle and varies with the fracture of the stone and with the diameter and spacing of the rolls. Fig. 10 and Table 1 show these variations quite clearly.

19 The Edison Portland Cement Company has kept an accurate Time Lost account with each piece of machinery. An accurate statement of the total number of minutes lost on each roll and the causes of such stoppage for the years 1909 and 1910 are given in Table 2. The total loss of time is 237 hours, out of a possible running time of 4814 hours. The total delays due to the 4 rolls, therefore, was 4.9 per cent of the possible running time, and the average tons crushed per operating hour was 224.

20 The actual cost of all material bought or manufactured by our shops for repairs on the rolls is available, but the actual labor of making the repairs cannot be accurately determined, since it is included in the item of repairs to the crusher, car hoist, dryers, conveyors, etc. The charges for material are itemized as follows:

Roll plates	$4454.90
Bearings	92.04
Gears, shafts, etc	732.78
Plate and coupling bolts	240.88
Hopper plates	242.88
Belts	2192.19
Miscellaneous	762.72
	$8718.39

21 During this time (two years) the plant reduced 1,024,409 tons of stone from 10-ton pieces, so that all would pass a $\frac{3}{4}$-in. screen. This makes a plate cost per ton of $0.0043; belt cost per ton of $0.0021; general repairs per ton of $0.0021 and total repairs per ton crushed of $0.0085.

22 All of these rolls are driven by a prime mover inadequate to start them from a state of rest, and it is necessary to use levers or some similar device in starting.

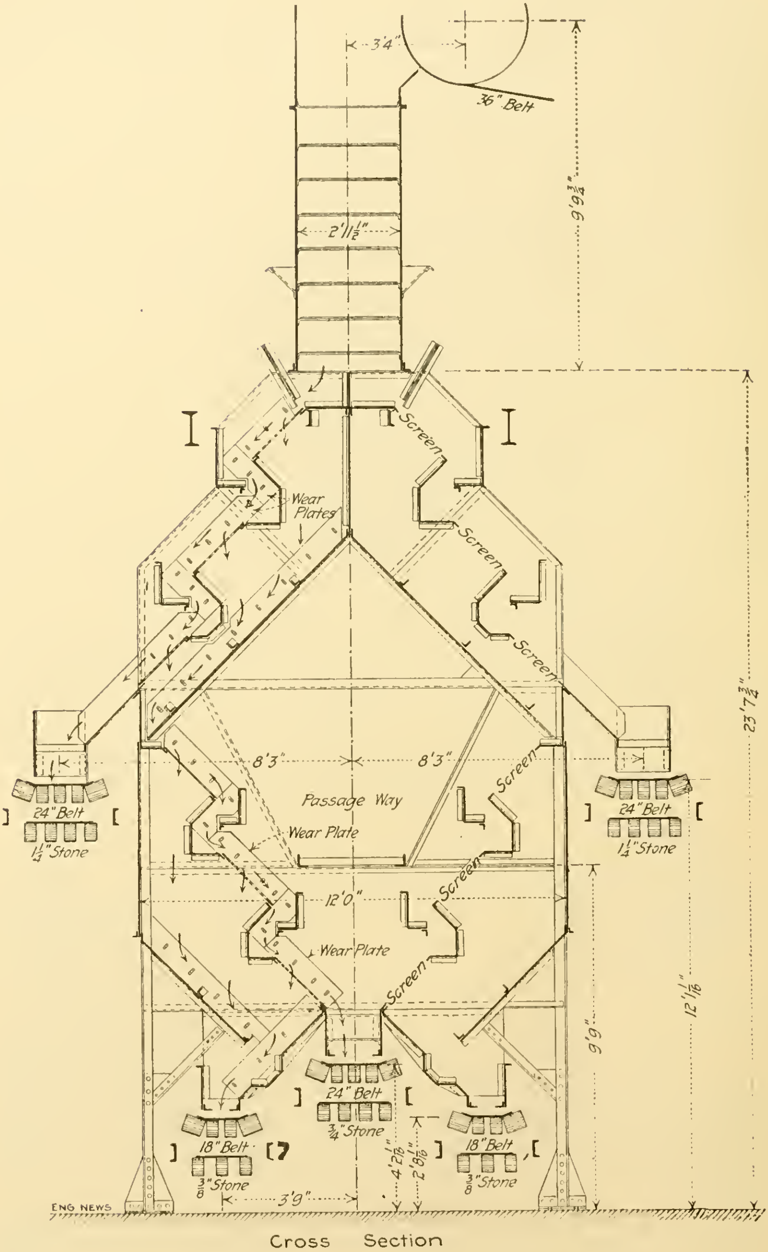

FIG. 11 SECTIONAL VIEW OF EDISON SIZING SCREEN

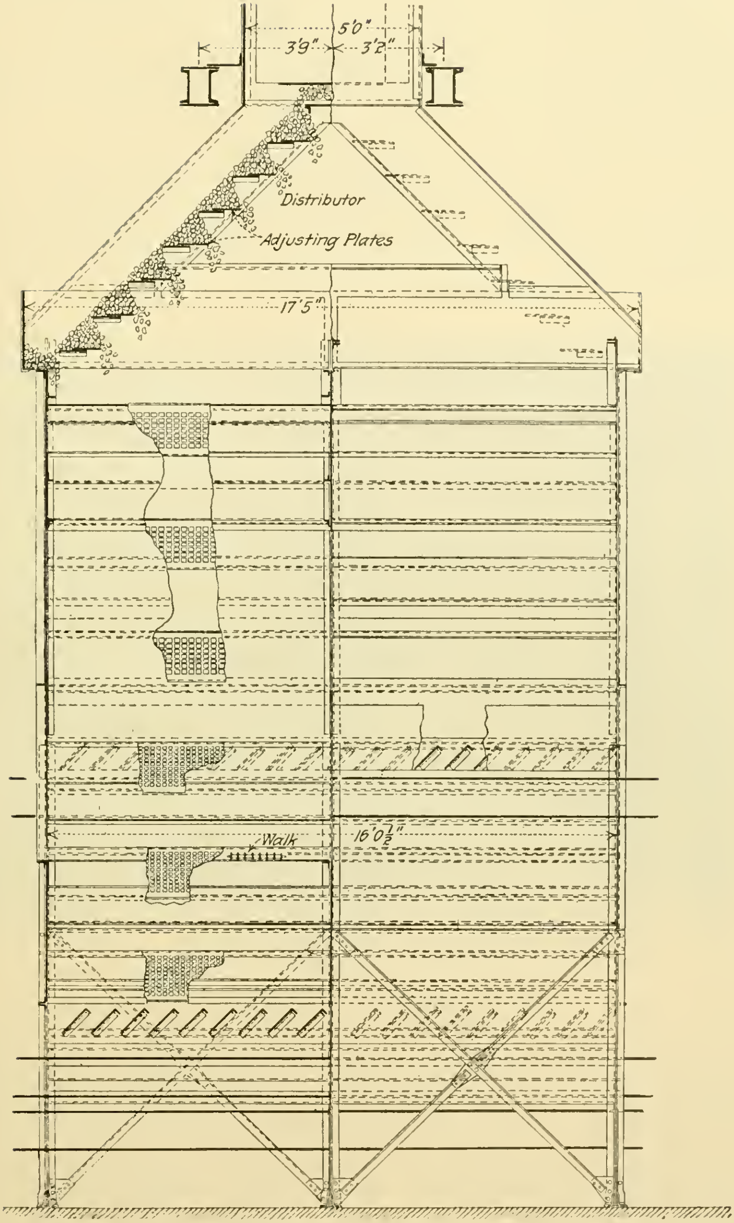

FIG. 12 END ELEVATION OF EDISON SIZING SCREEN

23 The strains set up when a 15-ton stone drops 10 ft. or more to the rolls are enormous, as are also the crushing strains, but they are largely taken up internally because the rolls act as an anvil. Only a comparatively small part of the shock is transmitted to the bearings or driving power.

24 The wearing surface of all the rolls is made of chilled cast-iron plates. On the giant rolls the chill is about 2 in. deep, while on the smaller rolls it is from $\frac{3}{4}$ in. to 1 in. deep. We have found that chilled iron, when properly made, wears much longer than manganese steel, and of course is much cheaper.

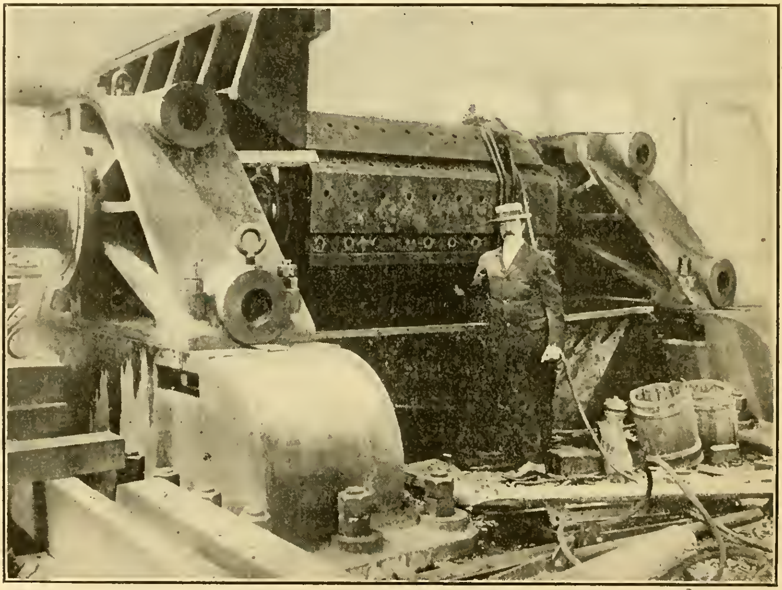

FIG. 13 GIANT ROLLS DURING ERECTION AT THE PLANT OF THE U. S. CRUSHED STONE COMPANY, CHICAGO

25 The capacity of the giant rolls is almost unlimited. In a recent test made on a pair of Edison rolls 6 ft. in diameter and 7 ft. long, 35 tons of stone were crushed in 32 seconds or at the rate of 4000 tons per hr. This was done at one of the quarries of the Kelly Island Lime and Transport Co. on a dolomite "run of quarry" loaded by steam shovels, the pieces being 4 to 5 tons or less. Side-dump cars were used on this test and they were arranged to dump automatically into the hopper over the rolls as the train was pulled by. It is needless to say that

at the end of the test the pan conveyor under the rolls was disabled and the rolls were running at a considerable reduction in speed.

26 The above figures may seem startling, but the theoretical capacity of the rolls is much greater when calculated on the same basis as that on which the capacity of smaller rolls is figured, and which the writer has frequently proved by actual tests to be correct.

27 The rolls are 6 ft. in diameter and 7 ft. long, are run at 185 r.p.m., and the average opening between the rolls is 9 in. This gives a surface speed to the rolls of 3487 ft. per min. or $\frac{3487 \times 7}{12} =$ 18,306 cu. ft. passed per minute. Assuming 20 cu. ft. per ton, this

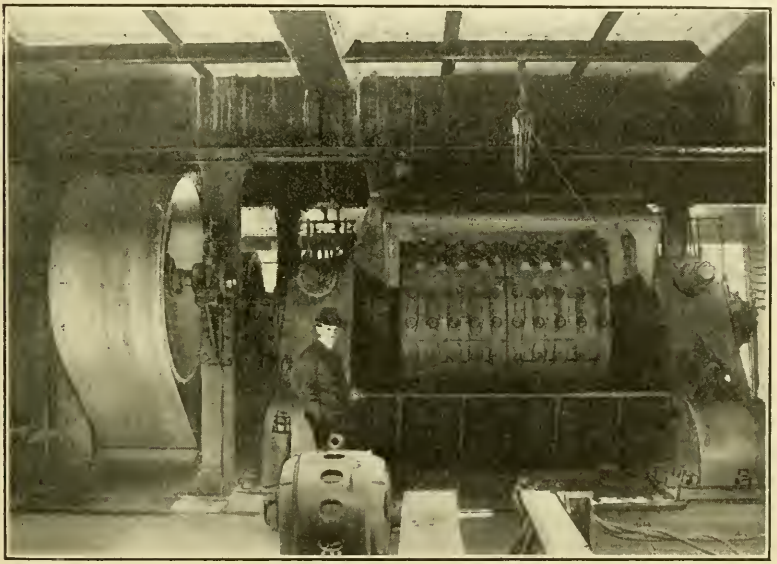

Fig. 14 Giant Rolls at Tomkins Cove—6 ft. by 7 ft.

would be equivalent to 915 tons per min., or about 55,000 tons per hr.

28 The average horsepower required to drive these rolls while crushing 3000 or 4000 tons per day is quite small, ranging between 100 and 150 h.p., but the momentary peak loads are very much greater. One of the companies operating a pair of these rolls 6 ft. by 7 ft., motor driven, buy their power with certain peak load specifications. In order to reduce the peaks they have set a circuit breaker to cut off the current at about the normal load of the motor. After the stone is

crushed the current is turned on the motor, and the roll again brought up to speed. It frequently happens that the current is cut off the motors by this method as many as 50 times a day.

29 Fig. 13 shows a set of 6 ft. by 7 ft. rolls being erected at the plant of the U.S. Crushed Stone Company, Chicago, Ill., and gives an idea of the heavy construction necessary to withstand the great shocks. This also shows the mandrels to which the plates are attached.

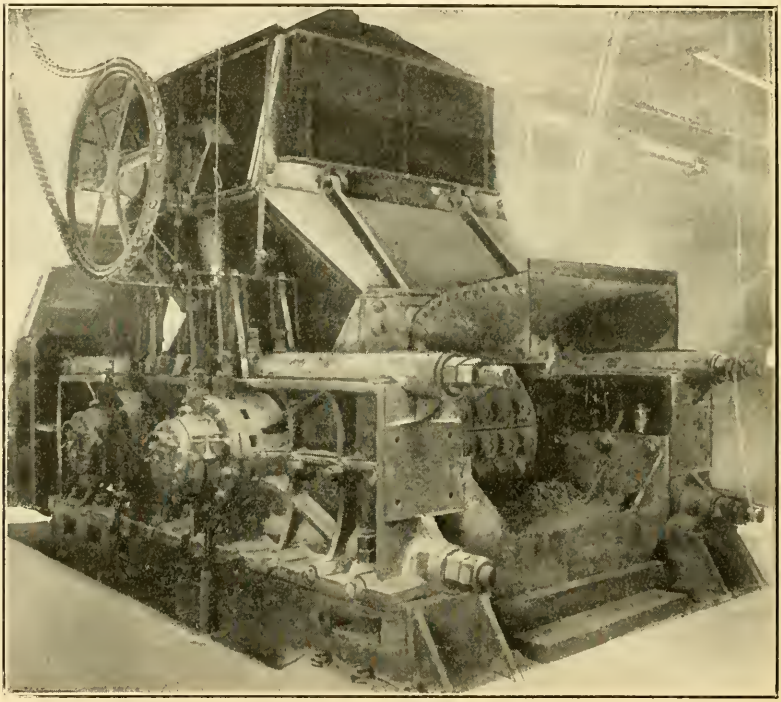

Fig. 15 Intermediate Rolls at Tomkins Cove—4 ft by 4 ft.

30 The crushing plant of the Tomkins Cove Stone Company, Tomkins Cove, N. Y.,[1] which was put in operation last fall, has, as far as the writer knows, the largest capacity of any plant in the world. Its extreme simplicity is one of the most striking features, and its design throughout is for a capacity of 1000 tons per hr. The stone,

[1] This plant was more fully described and illustrated in Engineering News, January 12, 1911.

after being loaded with steam shovels in the quarry, is dumped into a pair of 6 ft. by 7 ft. rolls, reducing it approximately to 8-in. sizes. Under these rolls there is a hopper having a capacity of about 30 tons. The stone is fed from this hopper by feed rolls to a set of 4 ft. by 4 ft. rolls, which run 250 r.p.m. This reduces the stone to about $3\frac{1}{2}$-in. sizes when it goes directly to a set of 4 ft. by 3 ft. rolls and is reduced to about $1\frac{1}{2}$ in. A large pan conveyor receives the stone and lifts it to an Edison stationary screen, which returns anything over $1\frac{1}{2}$-in. sizes to the lower rolls for re-crushing. The product from this

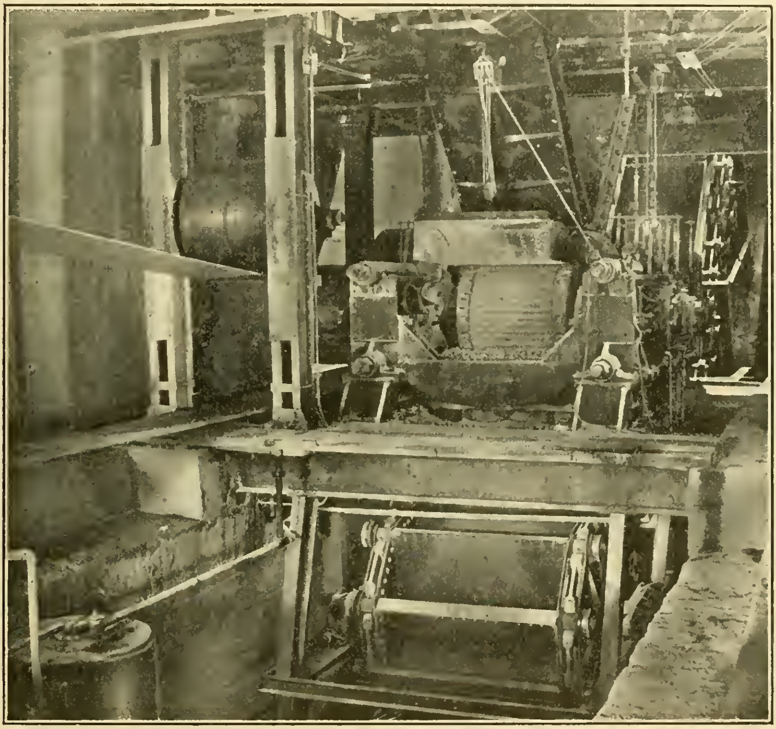

FIG. 16 FINAL ROLLS AT TOMKINS COVE—4 FT. BY 3 FT.

screen is carried by a 36-in. belt conveyor to the Edison sizing screens (Figs. 11 and 12). Here it is divided into three sizes, known commercially as $1\frac{1}{4}$-in. stone, $\frac{3}{4}$-in. stone and $\frac{3}{8}$-in. stone. It is carried by belt conveyors to concrete bins having a total capacity of 20,000 tons, from which it can be withdrawn and delivered by belt conveyors directly to barges or railroad cars.

31 The size of stone may be varied as desired by changing the openings between the rolls or the size of the openings on the screen plates.

32 Figs. 14, 15, 16 show the giant, intermediate and final rolls at the Tomkins Cove plant.

SOME PROBLEMS OF THE CEMENT INDUSTRY

By Walter S. Landis

ABSTRACT OF PAPER

Progress and improvement in the cement industry has and will resolve itself into the development of the plant as against the process. The chief features of interest in this plant development is the question of size of first crushing unit, the fineness of grinding of the raw materials before entering the kiln, the gradual displacement of the wet process by the dry one, better utilization of the fuel in the clinkering of the raw material, the abandonment of the air separator. The older mills must be remodelled along the lines of more economical power distribution and labor requirements to successfully compete with the modern mills, now that profits in cement manufacture have dropped so low.

SOME PROBLEMS OF THE CEMENT INDUSTRY

Walter S. Landis,[1] South Bethlehem, Pa.

Non-Member

If one were to ask the average mechanical engineer for information concerning the cement industry he would most likely be told that this industry belongs to the field of the chemist. This idea is quite as erroneous, as it is prevalent among mechanical engineers. It may be true that in the early days of the industry the chemist occupied the most important position, but today the mechanical engineer is at the head of our great plants and the chemist has degenerated into a very subordinate official. There are reasons for this change, the most important one being that it is easier for the mechanical engineer to pick up the necessary chemical knowledge than it is for the chemist to acquire the requisite mechanical training. Again, the rigid requirements as laid down by the early chemists for the manufacture of a passable product are no longer recognized as true since we have learned so much more about the technology of cement. As a result we have been having the development of the plant as against the process, and the mechanical engineer, of course, plays the most important part in such plant development.

2 What we today understand as Portland cement is a certain compound of silica, alumina and lime in the proportions of SiO_2, 20 to 23 per cent; Al_2O_3, 8 to 10 per cent; and CaO, 62 to 65 per cent. It is not possible to obtain these ingredients in large quantities in a state of absolute purity and we frequently find alumina replaced by ferric oxide, up to 3 per cent, and lime by magnesia, up to 2 or 3 per cent, so that actual cements as found on the market diverge slightly from the above analyses without, however, suffering greatly in their physical properties. It must also be remembered that the well-known Portland cement is only one of a dozen chemical compounds which

[1]Associate Professor of Metallurgy, Lehigh University.

harden or set when mixed with water and that it has attained its great importance because of the ease and cheapness with which it can be manufactured and not because of any peculiar properties not possessed by certain other compounds.

3 Simply the mechanical mixing of silica, alumina and lime in the above proportions will not yield a compound possessing the properties of Portland cement. It is essential that these ingredients be in a manner combined, not exactly as a true chemical compound, but rather as a physico-chemical solution of one or more chemical compounds in each other. The mixture must be finely ground before it will exhibit the characteristic setting property. The best and practically the only way in which such a union can be attained is by a complete or partial fusion of the silica, alumina and lime mixture. Such a partial fusing is called sintering or clinkering.

4 All the laws of physical chemistry relating to the formation of slags and fused mixtures apply also to the formation of the clinker, a few of the more important facts being here mentioned. The melting point and the clinkering temperature are dependent on the purity of the mass clinkered, being lowered by the presence of such impurities as oxide of iron, magnesia, alkalis, etc. It is a well-recognized fact that the so-called white or stainless cements require a much higher temperature for clinkering than the dark colored and more impure mixtures. The temperature required for clinker formation depends on the intimacy of the contact of the various clinkering ingredients, the finer the individual materials are ground the lower the temperature required.

5 Since we know that such a thing does not exist as an overburned cement, a fusion of the properly proportioned ingredients would solve the question of a homogeneous product. But such a fusion has not proved advisable in practice and the cement manufacturer has had to content himself with a sintered or clinkered product, that is, one which has been raised in temperature to a sticky or viscous stage and not actually liquified. As such clinkered product is at no time a mobile liquid we cannot depend on liquid diffusion for the proper mixing of the silica, alumina and lime but must do such mixing purposely. To ensure the necessary contact between these ingredients so that they can unite chemically to a homogeneous whole when in the state of only incipient fusion, they must be most finely ground and most thoroughly mixed. Therefore the first stage in all cement processes, as at present practiced, is a preliminary grinding and mixing of the raw materials.

6 The first consideration in the grinding of a material is a study of the properties of the material to be ground. This in turn leads us to a description of the raw materials entering into the manufacture of Portland cement. Of first importance among these is cement rock, an argillaceous limestone, lying both in composition and in geological position between the true limestones and the slates. It is a natural mixture of carbonate of lime and clay, which on heating to the clinkering temperature loses its combined water and carbonic acid and unites together into a fritted mass of the desired composition and properties. It is shaly in nature, not very hard, and of varying degrees of toughness. In several favored parts of the country, as for instance one or two places in the Lehigh Valley region, this rock needs no further treatment other than quarrying, comparatively coarse crushing and burning to form a first-class clinker. Usually the ingredients are not present in the natural rock in exactly the desired proportions and the one lacking, generally lime, must be added. Sometimes in this region there will be two strata or benches in the same quarry so constituted that by mixing rock from the two in certain proportions, the silica, alumina and lime will be in the desired proportions in the clinkered product.

7 Where materials are found to be so near the desired composition as to require practically no mixing, the grinding is a simple proposition. Only such fineness would be required, if the rock were of uniform composition, as would insure the kiln producing a properly burned product when run at a predetermined capacity. This would really be a sizing rather than a grinding. On the other hand, if the rock is non-homogeneous or requires some mixing to make a properly constituted clinker, then finer and finer and finer grinding, proportionate to the degree of non-homogeneity or amount of mixing required, must be done to enable the mixture to attain the composition desired in the clinker. No hard and fast rule can be laid down for the required fineness of grinding. It must be suited to the individual case, remembering that sometimes the financial success of the plant depends on making a passable product with the coarsest allowable grinding. The kiln temperature, as well as the length of time the mass is subjected to this temperature, influences the required fineness of grinding. The finer the grinding the easier the clinkering and, therefore, the capacity and coal consumption of the kilns are directly proportional to the fineness of the ground mix fed in. It has been found in practice within the past few years to be more economical to grind very fine before burning, even though such a degree of fineness of the raw material would

not actually be required to make a satisfactory clinker. In other words, the coal used to drive the grinding machines to produce this extra fineness is less than that saved in the kiln, and at the same time the capacity of the kiln is greatly increased. It has also been said, though I cannot verify it from actual observation, that the finer the grinding of the raw material the easier the clinker is to grind afterwards. This might be explained by the fact that the lower temperature at which the finer mix clinkers leads to the formation of a softer clinker. In that case the power put into the preliminary grinding would at least be partially saved in the finishing department. A more thorough study of this question is one of our problems.

8 But it must not be understood that the manufacture of cement is confined to those favored localities in which cement rock is found. A mixture of clay and limestone can be prepared artificially of such composition that when the combined water in the clay and the carbonic acid of the limestone are driven off by heating, the residue will form clinker of the desired composition. Here we have materials of entirely different composition and nature to be mixed, and the grinding of each must be exceptionally fine in order that they may combine under ecomonical conditions of kiln running. It is recognized by cement men that the manufacture of a satisfactory cement from limestone and clay entails a different mill equipment from that in use in the Lehigh Valley region, where the raw material is a nearly perfect cement rock. Such raw materials, to be properly mixed, *must* be ground so that practically all will pass a 100 mesh screen and nearly all a 200 mesh.

9 Other raw materials available are marl mixed with limestone or clay, shale mixed with limestone, and even blast-furnace slag mixed with limestone. This latter material is at present receiving a great deal of attention from cement men. The iron blast-furnace slag is composed of silica, lime and alumina, and by the addition of limestone, clinker of the desired composition can be produced. It has the advantage of being a waste product which the furnaces are glad to get rid of and at the same time needs no quarrying or coarse grinding, since it is granulated in water when tapped from the blast furnace. All materials like clay and limestone require exceedingly fine grinding (all through 100 mesh, 50–70 per cent through 200 mesh) in order to insure proper combination in the kiln.

10 It is not possible to discuss in detail the many problems connected with fine grinding of the large quantities of rock and clay which the cement industry handles. In quarrying the rock the percussion drill, such as is used in the digging of ordinary drilled wells, is largely

used for making the blasting holes, a series of holes being drilled along the face of the quarry 15 to 20 ft. back. The author has seen single blasts bring down from 20,000 to 40,000 tons of rock. After blasting, the rock is loaded up into dump cars in many quarries by the use of a steam shovel. These cars are moved to the foot of the hoisting incline by gravity or mule power, and are pulled up by a donkey engine. Considerable engineering skill must be brought to bear on the economical handling of the quarried rock in the quarry itself. After arriving at the top of the quarry the car is run into the crushing house, where the stone is weighed and dumped into the first crushing unit.

11 American and European practices differ in the size of this first crusher, which is almost universally of the gyratory type. With us, hand labor is expensive and must be dispensed with wherever possible. We therefore build this unit as large as is required to take any single piece of rock which the steam shovel can load into the dump car. When such a carload is dumped into the crusher the driving motor of the crusher suffers a momentary peak-load as the rock goes through, which load then drops off to nothing until the next car arrives. These crushers sometimes take a piece of rock 30 to 36 in. in diameter, using at the peak 250 h.p. In Europe, the rock as quarried is broken much smaller, usually by hand sledging, thereby permitting the use of a number of smaller gyratories, and so distributing the load on the motor more uniformly throughout the day. In our country the first large coarse crushers are followed by smaller ones of the same type, and in the newer mills these are driven from the same power source as the larger ones.

12 The advisability of using the very largest types of crushers made is a much discussed point among cement men. When one considers that the very large pieces of rock quarried are the exception rather than the rule and that the crusher is rarely called upon to take one the size of its opening, it seems questionable to fit a mill with such a machine. A stick of dynamite laid on such a large piece will easily reduce it to a size readily handled by the smaller crushers (even in this case larger than the European crushers), and so eliminate the enormous peak loads and expensive machinery. Several large new mills have not provided themselves with the largest procurable type of crushers made, even though their output would warrant it. This question of crusher size is another of the problems of cement manufacture awaiting final solution.

13 The drying of the product of the gyratories is the next stage in cement manufacture. The fineness to which the material is to be ultimately ground makes it necessary to remove all hygroscopic moist-

ure, otherwise clogging of screens and cutting down of capacity of the fine grinding mills would result. The driers are cylindrical steel shells capable of being rotated on their axes and are set slightly inclined in order to insure progressive motion of the charge through them. The wet, coarsely crushed material is fed in at the upper end and hot gaseous products from a coal fire or natural gas flame pass in at the lower end and over the charge to be dried. They are frequently provided with buckets, formed of Z-bars riveted to their inner surface, to pick up the rock and carry it part way around and so drop it through the gases passing through the drier and at the same time advance it through the kiln. At times they are divided into compartments to insure closer contact between the heating gases and the rock, but this design is gradually dropping out of use. The great decrease in capacity of a compartment drier over the ordinary type more than offsets the greater heat transfer from the gases to the feed. It is only recently that attempts have been made to utilize the hot gases from the kilns to perform the drying of the mix. Several such installations have recently been made and are working with great success.

14 The drying of clay for fine grinding presents an unusual problem, because after being dried it must be used immediately, as it again takes up moisture from the atmosphere. This usually results in a double drying operation: first just before disintegration, after which it goes into storage, and a second drying after lying in storage and just before final grinding.

15 From the driers the rock passes to one of the various types of fine grinding mills, such as the ball and tube mills, or mechanical mills like the Griffin and Fuller. The excellent catalogues furnished by the manufacturers of this class of machinery make it unnecessary to describe them in detail here and reference is made to them in full confidence in the reliability of the data there found. The product leaves these mills so finely ground that more than half of it will usually pass a screen of 200 meshes to the linear inch. It has been universal practice to fit the mechanical mills with screens (no screens in the tube mills) of 30 to 40 mesh openings, through which the product of the mill has to pass before discharge. Such screens are placed so that the material discharged from the mill strikes them at an acute angle and the full size of the opening is never available to the discharged product. Recently air separators have been tried as a substitute for the expensive and troublesome screens. The success of this installation is doubtful, for the conditions under which air separators work most efficiently are not the conditions under which ground material should

be prepared for the cement industry. A word of explanation will make this clear.

16 The screens having been entirely removed from the mill or replaced by much coarser ones permit a continuous supply of partially ground material to pass to the air separator for sizing, say to 100 or 200 mesh as desired, the oversize being returned to the mills for further grinding. With proper operation of such an air separator very little of the material will be ground finer than the air separator is adjusted to sort out. Now it is a well-known fact that the finer the materials entering into cement manufacture are ground, the better the product made. Since air separation furnishes a very uniformly sized product, this desirable extra fine grinding is eliminated. The screens, on the other hand, offer difficulty to the passage of product out of the mill, keeping a large part of the charge under grinding influence for some time after it has reached screen size, reducing it finer and finer in size. Thus some of the product discharged from a mill having 30 to 40 mesh screens may be 500 or 1000 mesh in size, a condition not realized in highly developed air separation. It is, however, admitted that air separation leads to greater capacity of output of the grinding unit, though at the expense of quality.

17 So far nothing has been said of the mixing of the raw materials to insure proper composition of the finished cement. This mixing practice has varied greatly. Originally the several ingredients were ground separately, mixed with water until thin enough to flow readily, and streams of each run upon a drying floor. Their fluidity insured mixing. After drying for some time, the mass was rolled into balls or pressed into bricks, and stored until ready for charging into the clinkering furnaces. Today this practice is obsolete and in its place we have the two great systems under which modern mills operate. They are known as the wet and the dry processes, their chief differences being based on the operation of mixing. In the wet process the two ingredients are ground separately, mixed with water until thin enough to flow, pumping assisting in this conveying if necessary, and are charged in approximately the desired proportions into large agitating tanks for mixing. The final adjustment of the composition is made in these tanks. The wet mixture is then pumped from these tanks directly to the kilns.

18 In the dry system the properly weighed and proportioned materials are first separately crushed in the coarse crushers, and are fed together into the fine grinding mills, practice varying somewhat as to the exact mill into which the two materials first come into contact.

The operation of grinding performs all the mixing required. For the same material it is supposed that finer preliminary grinding is more necessary in the dry process than in the wet for the same quality of cement. It seems to the author useless to add 50 to 100 per cent of water to a mass of ground material and then to evaporate that water again, when the dry process is working so satisfactorily.

19 Considerable changes have been made in the arrangement of the preliminary or raw grinding side of the mills as the industry developed. It is expensive to handle material and to transmit power. In the older days of the central power plant and lineshaft drive, the mills were arranged solely with a view to economy of power transmission and much handling of the material between the various crushing and grinding units was the result. Today the individual motor drive is supreme, with the result that I have seen modern mills so laid out that there is scarcely any handling of material in the whole grinding department, the first elevation occurring into bins above the kilns. Gravity was used to feed from one unit to the next. Such an arrangement is not always the most advantageous when it comes to a breakdown; and the mill must be built on a hill-side, which means awkwardness in handling repair parts. The ideal mill would probably require at least three elevators in this department, and since the power required by such elevators would be hardly over two or three per cent of the total power installation of the plant, it is really not a serious item.

20 Another feature of mill design receiving attention is storage capacity. The rough handling of the machines causes them, rugged as they are, to be laid off for repairs. It is necessary, to insure running of the mill to provide ample storage capacity between the various classes of grinding machinery so that a stoppage of one part will not cause the shutdown of the entire mill. Several very recent mills have provided storage capacity as follows: a 4-day supply of gyratory discharge, a 12-hour supply of ball mill feed, a 12-hour supply of finishing mill feed and a 24-hour supply of kiln feed. It must be remembered that climatic conditions have a marked influence on the consideration of storage capacity.

21 The kilns originally used for burning the mix to clinker were fixed, vertical, bottle-shaped furnaces. The balls or bricks made by the old wet process previously described were fed in at the top and the burned product drawn out at the bottom. The product was so irregularly burned that hand sorting had to be employed to pick out the underburned product, this portion containing uncombined lime and not

being suitable for the manufacture of a sound cement. While the fuel consumption of such a kiln is much below that of the usual rotary kiln, the labor and attendance charges are very high and the apparatus has been obsolete in this country for many years. Even Germany, a country of cheap labor, is now replacing this type of kiln by our own rotary design.

22 The modern rotary kiln consists of a cylindrical steel shell lined with refractory material and supported on rollers in cradles, its axis being slightly inclined from the horizontal. A rotation on its bearings is secured through one of the many types of variable-speed transmission. Its upper end enters into what is called the chimney hood, a dust trap and chimney support combined, and its lower end into another movable hood adapted for the discharge of clinker and the entry of fuel nozzles for pulverized coal, gas or oil. Pulverized coal is the most widely used fuel in cement burning. In size these kilns vary from 60 ft long and 5 ft. in diameter up to 240 ft. long and 12 ft. in diameter. The output of a kiln is not easily determined, as it varies much with the nature of the product to be clinkered, the degree of fineness of the feed, the moisture to be evaporated, and whether the driving demands is for efficiency of operation or for capacity. Great capacity is not synonymous with high efficiency in a cement kiln. For example, a 60-ft. kiln in the Lehigh region will have a capacity of 200 bbl. of clinker per day and the 240-ft. kiln of approximately 2500 bbl. per day. The lining of the kiln, at least at the hot end, is either of bauxite or magnesite brick in the majority of installations, though a highly refractory fire-clay may be used. Either of the first two linings are of a much higher heat conductivity than the latter.

23 One of the features of kiln design needing the attention of the fuel engineer is the stack. One sees on the same sized kilns stacks of all heights and diameters and not all can be highly efficient and economical. Some steps should be taken to investigate this question and to formulate a standard design embodying economy and efficiency.

24 Some of the finely ground material fed into the kiln is picked up by the gases passing through the kiln and passes into the chimney. Provision must be made in its design for settling out as much as possible of this dust, and too often one sees a narrow chimney on a kiln carrying out clouds of finely ground material and scattering it for miles over the surrounding country. This material consists of the extreme fines so to be greatly desired in the product.

25 The physical and chemical reactions taking place in the raw material as it passes through the kiln, starting with its charging at the

higher or chimney end of the kiln are as follows: rise in temperature accompanied by evaporation of water, if present, such evaporation holding the temperature constant at about 100 deg. cent. in the wet processes; rise in temperature up to about 300 deg. cent. where any chemically combined water such as occurs in clay is driven off, the rise being less rapid during such dissociation; rise in temperature up to about 800 deg. cent., where the carbonic acid of the limestone is driven off, the rise in temperature being again sharply checked by the heat absorption occasioned by this decomposition; a rise in temperature up to that of clinkering, 1200 to 1400 deg. cent., depending on the various conditions existing in the chemical composition and physical properties of the mix as already discussed; rapid rise in temperature to a maximum, at times higher than the temperature of the flame in the kiln, due to the heat of combination of the ingredients in forming the clinker; rapid drop in temperature as the material is discharged from the kiln. It is not possible to define in feet and inches the length of each zone because of the variable character of the raw material in each cement producing district and of the great differences of kiln length. A specific case was discussed in the paper[1], read before the Society by Mr. Soper in November 1910.

26 If we consider for the time being the charge of a kiln in the Lehigh Valley region where cement rock and the dry process are used, the net heat required by the above chemical reactions would be furnished by the combustion of about 16 lb. of average long-flame bituminous coal per barrel of clinker formed. This amount would be increased where clay and the wet process are used because of the heat absorbed in evaporating water and decomposing the hydrated compounds. The average fuel consumption of coal-fired cement kilns throughout the country is about 90 lb. of coal per bbl. of clinker, the calorific value of the difference between this figure and the one just given being lost as sensible heat in the discharged clinker and chimney gases and by radiation and conduction from the kiln shell. Waste of fuel of this magnitude should certainly appeal to the fuel engineer as well worthy of attention, particularly if he considers the magnitude of the industry. In 1910 this country made nearly 70,000,000 bbl. of cement. It is only recently that intelligent attempts have been made to reduce the heat losses of the kiln, or to utilize the waste heat in other operations. A feeble attempt has been made in

[1]The Rotary Cement Kiln, by Ellis Soper, published in The Journal for October, 1910.

this country to pass the hot chimney gases (temperatures averaging 500 deg. cent.) through the driers and so eliminate the extra fuel required in that part of the plant. Such installations are very successful. The regeneration of the heat in the discharged clinker by passing it through an under-cooler and preheating the incoming air has not proved satisfactory in many installations because of the stupidity of the operators. Where properly run, this system is saving hundreds of tons of coal per year. The main trouble has been that the kilns became too hot and the clinker stuck to the sides, all because the kiln manager did not deem it necessary to cut down the fuel when heat units were fed in another manner. German cement manufacturers used both the dryer and the under-cooler with their kilns almost from the introduction of the rotary type. It is only since the publication by the author of figures on radiation from kilns and the means of reducing such losses, that attempts have been made to save fuel by the installation as a backing to the usual kiln lining of a new heat insulating material.

27 It is not impossible to conceive of the use of a different and more efficient type of furnace than the rotary kiln for performing the clinkering operation. Surely fuel engineers have a prize well worth striving for when one considers that a saving of 10 to 15 lb. of coal per bbl. of clinker means a saving of three-quarter of a million dollars annually to the cement industry.

28 The clinker, after leaving the kiln, is passed through a series of cooling devices to dissipate quickly the heat it contains, and is then stored in heaps in the weather to age. Cement that has been underburned or improperly mixed so that it contains free lime will not pass the boiling test. If allowed to remain in the weather for some time so as to slake this lime and even lose some of it by solution, the cement prepared from such weathered product is generally of improved quality. The aging of clinker renders it softer and more easily ground, increasing the output of the grinding mills as much as 50 per cent. The elevators and overhead devices needed to handle such a storage are not expensive or complicated. The increased capacity of the grinding machines more than off-sets the power required by the conveying and storage machinery, and it is believed that the consequent ability to grind finer also offsets the bad effects of any uncombined lime which may be present.

29 After being recovered from the aging heaps the clinker passes into the final grinding department of the mill. This is similar to the raw grinding department, with the omission of the gyratories and dry-

ers. Gypsum is mixed with the clinker and the mass then passes to the grinding mills to be again reduced in size. As we have seen that clinker may lie exposed to the weather without taking up water, there must be a maximum size of particle which will combine it with water. This has been variously placed at about 150 mesh size, all particles coarser than that being inert in the finished cement. For this reason it is necessary to grind so that the greater proportion of the product will again pass through the 200 mesh screen. After this grinding the cement passes to the stock house, where it is stored for packing and shipment. It is now packed by automatic weighing and packing machines, in barrels and bags, the latter predominating.

30 It is not possible here to take up the important subject of conveying machinery as applied to the cement mill. Practice has greatly standardized itself in this respect into the use of buckets for elevating, air not proving successful. Lump material like clinker is carried on belts or by drags, and the screw conveyor has no great competitor in the conveying of fine material.

31 The power required for driving the mill varies very much with the type of installation. With the old shaft drive it was not infrequent to use $1\frac{3}{4}$ h.p. per bbl. of output per day. Some of the new motor-driven plants use as low as $\frac{2}{3}$ h.p. per bbl. per day, and the average throughout the country is not far from $1\frac{1}{4}$ h.p. With the decreasing profit in cement manufacture the difference between the minimum and the average power requirements as given above should be sufficient to cause a remodelling of power plants and transmission machinery in the older mills. The gas engine should find a growing field in this industry because the individual machines lend themselves so readily to motor driving. The labor requirements of the various mills seems to run parallel with the power requirement. In the older mills 8 bbl. of cement per day per man employed was a good average, while the newer mills are producing 16 bbl.

32 Cost figures are difficult to obtain in any privately controlled and competitive industry, and the cement industry is no exception. In a recent presidential address before a scientific society the cost of cement production was placed at 12 lb. for 1 cent, or 33 cents per bbl. Where such figures were obtained is a source of wonder to the author, unless it was from the published figures given some years ago for a western plant which is now in receivers hands and has not been operated for many years. No mill in this country is producing at this figure, which is not large enough to include fuel and labor costs alone at the majority of mills in the country. The Lehigh region is pro-

ducing cement as cheaply as any district in the country and we have to strive hard to cut the total cost at the mill below 55 to 60 cents per bbl.

33 In the above brief review of the industry the author trusts that he has considered a few of the problems that are confronting cement manufacturers. It will readily be seen that they are almost wholly of a mechanical nature and will offer sufficient inducements to attract the members of such a society as this to coöperate in their solution.

MILLING CUTTERS AND THEIR EFFICIENCY

By A. L. DeLeeuw

ABSTRACT OF PAPER

Observations of present day practice and a number of experiments point to the fact that better results can be had from milling cutters by increasing the tooth space and depth. A number of cutters constructed along these lines were tested and it was found that they have a number of points in their favor among which are less consumption of power, a greater amount of work done for one sharpening and a greater number of possible sharpenings per cutter. A change in the form of chip breaker made it possible to use cutters with chip breakers for finishing, as well as for roughing. It was further found advisable to use a special kind of key, here described, for heavy work. Finally, this paper describes a new style of face mill and what is called a helical mill.

A number of diagrams are presented showing the relative efficiency of different styles of mills for removing a given amount of metal. In general, attention is called to the possibilities which lie in a more scientific construction of milling cutters and the desirability of discarding our ideas of milling cutters, which are largely based on conditions no longer existing.

MILLING CUTTERS AND THEIR EFFICIENCY

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Member of the Society.

The amount of metal which a machine tool can remove in a given time is limited by the strains caused by the cut. Great hardness of the material to be cut, or a dull tool, will severely strain the machine and so reduce the section of the chip, even if the machine is rigidly constructed and well supplied with driving power. It is therefore of the greatest importance to analyze carefully all the conditions which cause heavy strains so that they may be obviated or reduced to the lowest possible limit.

2 This limitation of the cutting capacity occurs in all metal cutting machines, although to a varying extent. While it is possible to increase the driving power of most machines ad-libitum, and almost any amount of metal can be put into machine elements to give them rigidity, there are certain classes of machines where practical considerations limit such increase of power and strength. This is especially true in machines where the main elements have to be adjusted and handled with great frequency. The knee-and-column type of milling machine owes its success, to a large extent, to the ease and rapidity with which it can be manipulated and it is doubtful if it will ever be possible to increase the dimensions of the parts much beyond the present sizes, without losing the benefits of the peculiar construction of this type of machine. In order to increase the capacity of this type of milling machine, it becomes necessary to reduce the strains set up by the cut and there are only two elements which can be modified to accomplish this result. These are the hardness of the metal to be cut and the cutting qualities of the milling cutter. As it is impossible to control the first of these, the only avenue left for improvement leads in the direction of the milling cutter.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

3 Experiments carried on at the works of the Cincinnati Milling Machine Company and extending over several years, starting with some isolated and almost desultory trials, and gradually becoming a series of carefully planned experiments, have led to results which are believed to be of general interest. These tests embraced spiral mills, end mills, both of the shell end-mill type and the spiral taper-shank type, side mills, slitting saws, face mills, and a new type of mill which for lack of a better name is called here a helical mill.

4 The action of the ordinary milling cutter is not a true cutting action, as it is commonly understood. By a true cutting action is meant the driving of a wedge-shaped tool between the work and the chip and although this definition is not based on a generally accepted meaning of the term it is believed that it expresses fairly well what most mechanics understand by cutting. Practically all milling cutters have their teeth radial and this, of course, excludes the possibility of driving a wedge between chip and work. The tooth compresses the metal until it produces a strain great enough to cause a plane of cleavage at some angle with the direction of the cutter. It then begins to compress a new piece, push it off, and so on. This at least *seems* to be the action of the cutter, judging by the form of the chips. These chips are in the form of needles or small bars.

5 The chip taken by a milling cutter varies very materially from those taken by a lathe or planer tool. These latter tools make chips of uniform section, whereas the section of a milling chip increases from zero to a maximum.

6 Fig. 1 shows a milling chip as it would appear, if no compression or distortion took place. The proportions are very much exaggerated, so as to bring its typical shape clearer into view. The width AB at the top is equal to the feed per tooth. The height BC is the depth of cut. The length BD is the width of cut. The section $MNOP$, shown half way on the chip, is a normal section and a measure of the amount of work which was done at the time the cutter passed the point M.

7 Fig. 2 shows the action of a milling cutter, with center O, when the cutter is rotating and the work is feeding at the same time. The tooth AB sweeps through the path BC. When the point B has reached the position B_1 a new tooth starts cutting. By this time O has advanced to position O_2, and the new tooth A_2 B_2 is not yet in a vertical position, when the point B_2 touches the work. When the cutter revolves, this point B_2 must penetrate into the work and compress the metal of the work. The result will be spring in the arbor. When this

spring has assumed certain proportions, the blade or tooth begins to remove a chip. This may be assumed to take place in the position B_3, the tooth simply gliding over the work from B_2 to B_3. This action must necessarily be very harmful to the cutter, and, it was believed that this, perhaps more than any other action of the cutter, caused its dulling. It would be especially severe with light cuts, as a relatively small amount of spring would allow the point B_2 to travel through a large arc. It would be quite possible that a tooth should fail entirely to take a chip, and that the succeeding tooth would take a chip of double the amount.

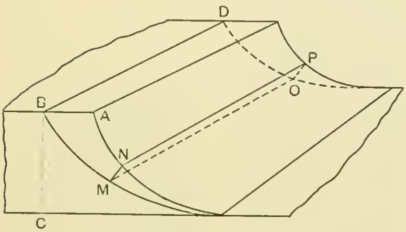


FIG. 1

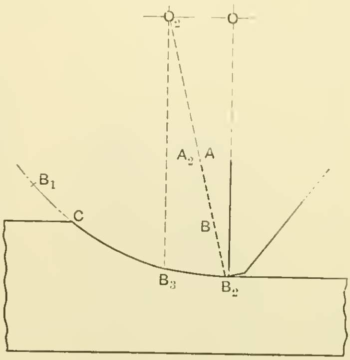


FIG. 2

FIG. 1 METAL CHIP ASSUMED TO BE PRODUCED BY MILLING-CUTTER WITHOUT DISTORTION

FIG. 2 DIAGRAM TO ILLUSTRATE ACTION OF MILLING-CUTTER

8 This peculiar action of the milling cutter is inherent in its construction and cannot be avoided. The question then is how to minimize these harmful results.

9 Another feature, which limits the ability of a milling cutter to remove metal, is the proportion between the chip to be removed and the amount of space between two adjoining teeth. Such a limitation does not exist with lathe or planer tools, where the chips have unlimited space in which to flow off.

10 That this proportion between chip and chip space actually does form a limiting condition is well known and was brought most forcibly to the writer's attention when a large and powerful machine stalled, taking a cut in cast iron about $1\frac{1}{2}$ in. wide, $\frac{3}{16}$ in. deep and $12\frac{1}{2}$ in. feed per minute. Several times this amount of metal can be easily removed by the same machine, without sign of stress; yet the machine was incapable of removing more than 3 cu. in. of cast iron

per minute with this cut. Investigation showed that the amount of cast iron removed per tooth was sufficient to fill the chip space completely, and from that moment the action was like trying to push a solid bar of steel through a piece of cast iron. Another cutter, with more chip space, removed the same amount of metal with only a fraction of the power of the machine.

11 Similar instances occurred with gangs which had been in use a long time, and which had been ground down to such an extent that the chip space was materially reduced. This, combined with the fact that higher developed milling machines led the shop to coarser feeds, showed that the ability of the machine to remove metal was not only governed by its power, but to an equal extent by the peculiarities of the milling cutter.

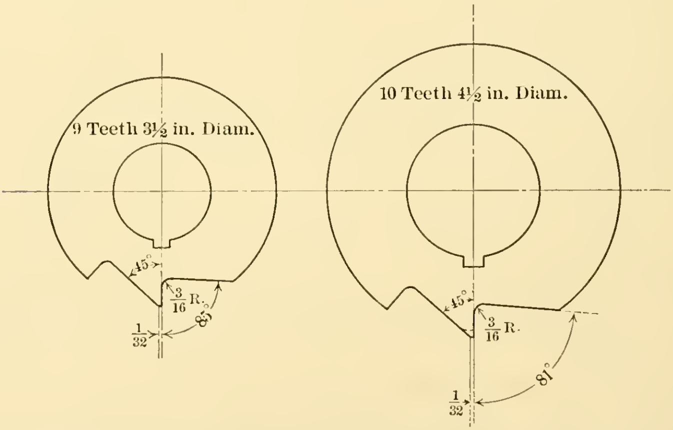


Fig. 3 Form of Spiral Milling-Cutters now used by the Cincinnati Milling Machine Company

12 The foregoing considerations led to a gradual evolution of spiral milling cutters. At first, the number of teeth of spiral mills was only slightly diminished, as it was thought that some element which was not considered might affect the result. Gradually the spacing was increased and the cutters, as now used, have taken the forms shown in Figs. 3 and 4.

13 Two standard sizes are used, although other sizes are required for special cutters and special gangs. The standard diameters are $3\frac{1}{2}$ in. and $4\frac{1}{2}$ in. The $3\frac{1}{2}$-in. diameter cutters are made with nine, and the $4\frac{1}{2}$-in. diameter cutters with ten teeth, which corresponds to a spacing of about $1\frac{1}{4}$ in. The point of the tooth has a land of $\frac{1}{32}$ in.,

and the back of the tooth forms an angle of 45 deg. with the radial line. The chip space is approximately four times as great as in the usual standard cutter of the present time and is formed with a $\frac{3}{16}$-in. radius at the bottom.

14 Though not directly connected with the foregoing, attention should be called to the fact that present practice calls for arbors which are too small. In the cutters shown here, the $3\frac{1}{2}$-in. cutter is made with $1\frac{1}{2}$-in. and $1\frac{3}{4}$-in. arbor, and the $4\frac{1}{2}$-in. cutter with $1\frac{3}{4}$-in. and 2-in. arbor.

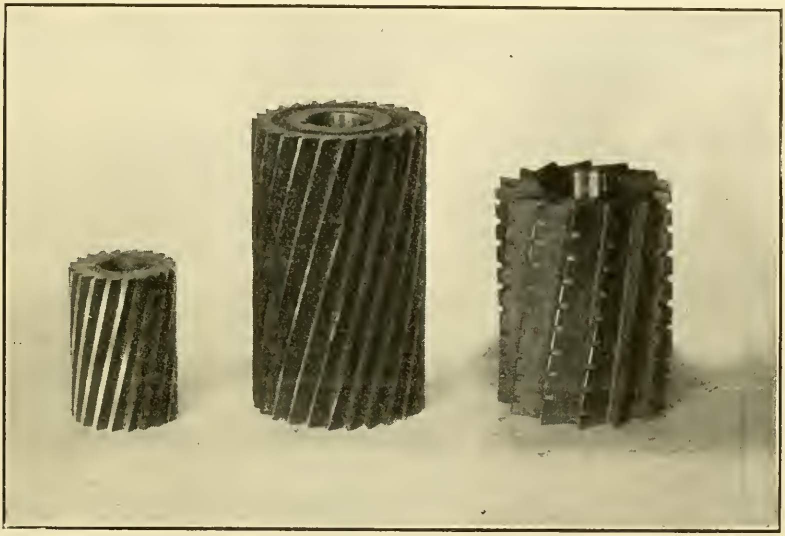
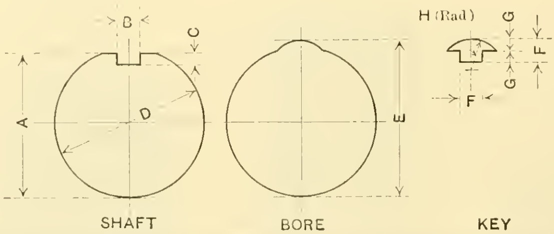


Fig. 4 Comparison of Old and New Style Spiral Mills

15 It is often very difficult to remove cutters from an arbor after they have done heavy work. It is frequently necessary in such cases to press the arbor out of the cutters. This sticking of the cutter is caused by the burring up of the key, and often the keyway in the arbor. For this reason, keys are used for gangs of cutters as shown in Fig. 5. A flat is milled on the arbor, and the keyway milled central with this flat. The flat portion of the key presses against the flat part of the arbor, and this effectively prevents burring. Cutters which are held on the arbor with such a key can always be very readily removed, even after prolonged and hard work. The keys are made out of a piece of round stock, grooved at both sides and then sawed apart.

16 Very satisfactory results were obtained with these cutters. Figs. 6, 7 and 8 show the results of tests made with cutters with $\frac{5}{8}$ in., $\frac{3}{4}$ in. and $1\frac{1}{8}$ in. spacing. Cuts were taken on cast-iron test blocks as shown in Fig. 9. The cross-sectioned part of the test block was milled out. A series of tests was made on the left-hand half of the block with one kind of cutter and on the right-hand half with another cutter. It will be noticed that the same amount of power is required to take a cut $\frac{1}{4}$ in. deep and with 10.4 feed with a cutter of $\frac{5}{8}$ in. pitch; and a cut $\frac{1}{4}$ in. deep and with 13.5 feed but with a cutter of $1\frac{1}{8}$ in. pitch.

17 It was not safe to assume that all test blocks would be of the same hardness. In order to correct whatever error there might be



A	B	C	D	E	F	G	H
0.973672	$\frac{5}{32}$	$\frac{5}{64}$	1	1.05179	$\frac{5}{32}$	$\frac{5}{64}$	$\frac{12}{64}$
1.03779	$\frac{5}{32}$	$\frac{5}{64}$	$1\frac{1}{16}$	1.11592	$\frac{5}{32}$	$\frac{5}{64}$	$\frac{13}{64}$
1.21875	$\frac{3}{16}$	$\frac{3}{32}$	$1\frac{1}{4}$	1.3125	$\frac{3}{16}$	$\frac{3}{32}$	$\frac{1}{4}$
1.4543	$\frac{1}{4}$	$\frac{1}{8}$	$1\frac{1}{2}$	1.5793	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{21}{64}$
1.7111	$\frac{1}{4}$	$\frac{1}{8}$	$1\frac{3}{4}$	1.8361	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{21}{64}$
1.94734	$\frac{5}{16}$	$\frac{5}{32}$	2	2.10359	$\frac{5}{16}$	$\frac{5}{32}$	$\frac{13}{32}$

Fig. 5 Shape and Dimensions of Keys used for Milling-Cutter Arbors

on account of unequal hardness of the test blocks, hardness tests were made of the different blocks. These consisted in taking a cut $\frac{3}{16}$ in. deep and with various feeds on each one of the blocks, and finally a check test on the first block, to make sure that the cutter had not appreciably dulled.

18 It will be seen from these diagrams that there is a large increase in the amount of metal which can be removed with the same amount of horsepower, by using these wide-spaced cutters; and that, therefore, the scope of the knee-and-column type of milling machine has been enlarged without increasing sizes or weight of parts and thus decreasing the handiness of the machines.

19 Though increased capacity for removing metal is one of the main advantages of this form of cutter, there are others of consider-

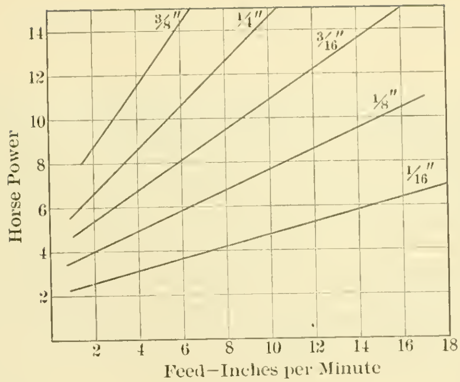


FIG. 6 TESTS OF SPIRAL NICKED MILLING CUTTER $3\frac{23}{32}$ IN. DIAMETER; 18 TEETH AND ABOUT $\frac{5}{8}$ IN. PITCH. CUTTING CAST IRON CORRECTED FOR HARDNESS. WIDTH OF CUT 6 IN.

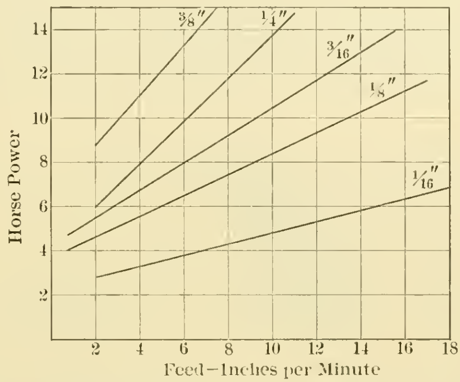


FIG. 7 TESTS OF SPIRAL NICKED MILLING-CUTTER $3\frac{1}{2}$ IN. DIAMETER; 14 TEETH AND ABOUT $\frac{3}{4}$ IN. PITCH. CUTTING CAST IRON, CORRECTED FOR HARDNESS. WIDTH OF CUT 6 IN.

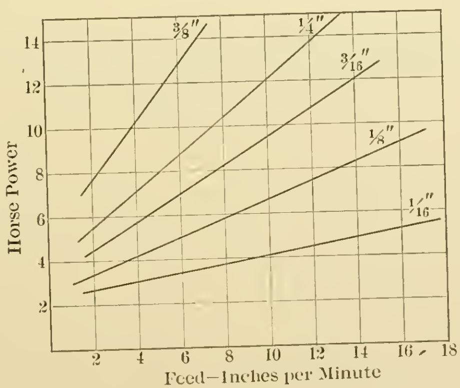


FIG. 8 TESTS OF SPIRAL NICKED MILLING-CUTTER 6 IN. DIAMETER; 16 TEETH AND ABOUT $1\frac{1}{8}$ IN. PITCH. CUTTING CAST IRON, CORRECTED FOR HARDNESS. WIDTH OF CUT 6 IN.

able importance. It was found that for roughing on the ordinary work in the shop a cutter with the wider-spaced teeth would remain sharp for a longer period, notwithstanding that feeds had been increased. The system of the Cincinnati Milling Machine Company requires all gangs and cutters to be re-sharpened after a lot of pieces has been milled. It used to be necessary, at least on the larger lots, to re-sharpen the gang once and sometimes twice for one lot, or, if this was not deemed advisable, the feed had to be reduced for at least part of the pieces, in order to make the cutter last during the entire lot. In all cases where the wide-spaced cutters were used, the entire lot was run through without re-sharpening the cutter or reducing the feed; and it should be kept in mind that this feed was from 25 to 100 per cent greater than previously used. There is no case on record where the cutter or gang was dull at the end of the lot, so that our observations as to the endurance of the cutters are incomplete. However, it is perfectly safe to say, that in all cases under observation the cutter

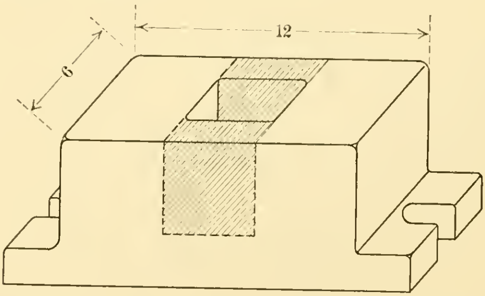


Fig. 9 Test Block used in Testing Cutters with Different Spacing of Teeth

maintained its sharpness longer; that in a great many cases double the amount of work could be done without re-sharpening; and that there is good reason to believe an even greater gain than this was obtained.

20 A further advantage is, that as these cutters have approximately only half the number of teeth of what is now considered a standard cutter, the time for re-sharpening is only half as much.

21 It was pointed out that the ratio of pitch to depth is practically the same as in the present standard cutter, so that the depth of tooth is practically doubled and this cutter can be sharpened much more frequently than the present standard cutter. Consequently the life of the cutter has been much increased, probably more than doubled.

22 A glance at the drawing of these cutters gives the impression that the teeth are weak and the writer has watched this feature with great care. The cutters themselves, however, do not give this impression; on the contrary, they look stout and well proportioned. They have been subjected to the heaviest class of work and many times were purposely abused in order to find their weak points; yet there is no case on record that any of them have broken although they have been used for more than two years and all breakages of cutters are carefully noted. On the other hand, breakages of the old cutters are not at all infrequent.

23 Though these cutters are capable of removing metal more rapidly than the older type of cutter there are many cases where this feature cannot be taken advantage of, as, for instance, where light work is to be done or a small amount of stock to be removed. In such cases, however, the metal is removed with less power and consequently with less strain on the machine and the life of the machine is lengthened without limiting its output.

24 With the wide spacing of the teeth it may seem that there would be cause for apprehension as to the action of the feed. It seems as if the feed would be liable to act with jerks. This, however, is not the case. On the contrary, the feed is smoother and there is less of a jerk when the cutter first strikes the work, probably because there is less spring in the arbor and less tendency for the cutter to ride over the work, as will be explained later in connection with the description of cutters.

25 In connection with this, it is interesting to note that when cast iron is milled by these wide-spaced cutters, it appears to be very soft and when the same piece is milled by an old-style cutter, it appears to be much harder. When using the wide-spaced cutter, there is a notable absence of jerking, chattering and of the peculiar singing noise which is so often noticed on milling machines.

26 There is, of course, a difference in the hardness of different pieces of cast iron, and many recommendations as to the proper feeds and speeds for milling cast-iron work, made by the writer for the his Company, were looked at askance. The impression seemed to prevail that feeds and speeds which were possible on American iron, were out of the question on European iron, (especially English and German); and again, that feeds and speeds proper for western American iron were not suitable for eastern iron. To test the truth of the matter, a number of bars of cast iron were obtained from different foundries in America, England, France and Germany.

These bars covered a great many mixtures and makes, and the difference between English and American, or German and American iron, or between eastern American and western iron, was found to be no greater than that between different specimens of western American iron. Even German Spiegeleisen, famous for its hardness, cut just as freely as soft western iron, and required but little more power. However, it did require more clearance, wide spaces, and a low speed.

27 These wide-spaced cutters were originally intended for roughing operations only, but the very satisfactory finish obtained when roughing led to the use of the cutters for finishing also. If there is any difference at all in the finish produced, the advantage is on the side of the wide-spaced cutter. The fact that this wide-spaced cutter will cut a greater number of pieces without dulling, means, of course, that the average finish of an entire lot is better.

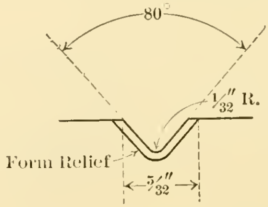


Fig. 10 Chip Breaker, Double Size

28 It is generally believed that for finishing alone a milling cutter should be used without chip breakers, the effect of the chip breaker being to scratch the surface. To overcome this trouble, chip breakers are made as shown in Fig. 10 with clearance at both corners. This prevents the tearing up of metal with the result that a cutter with these chip breakers produces as good a finish as one without chip breakers.

29 It should be pointed out that this form of chip breaker has an advantage also for roughing cuts. The point of the cutter, where the unrelieved side of the chip breaker drags over the work, is the first point to give out. Making the chip breaker with clearance on both edges prolongs, therefore, the life of the cutter.

30 One of the great advantages of this form of chip breaker is, that one gang can be used for both roughing and finishing. A great many, if not most milling operations, call for two chuckings, one for roughing, and one for finishing. This will be found to be necessary

wherever much metal is to be removed, on account of distortion caused by the cut, the heavy clamping required, heating, spring of arbor or fixture and the unbalanced condition of the work after the scale has been removed on one side. In order to do the roughing as rapidly as possible chip breakers are required; and in order to get proper finish, it has heretofore been necessary that the finishing gang be without chip breakers. It paid, therefore, to have two gangs whenever the number of pieces to be milled was sufficiently large, but this involved considerable extra expense for cutters. The new form of chip breaker, however, permits using one gang for both finishing and roughing.

31 It is a common belief that better finish can be obtained with teeth closely spaced, but experience with the wide-spaced cutter shows that there is no ground for this belief. The grade of finish may be expressed by the distance between successive marks on the work. These marks are revolution marks and not tooth marks. It is practically impossible to avoid these revolution marks. They are caused by the cutter not being exactly round or quite concentric with the hole, by the hole not being of exactly the same size as the arbor, by the arbor not being round, by the straight part of the arbor not being concentric with the taper shank, by the taper shank not being round or of the same taper exactly as the taper hole in the spindle, by this taper hole being out of line with the spindle, by looseness between the spindle and its bearings, etc. Each of these items is very small in any good milling machine; yet the accumulation of these little errors is sufficient to cause a mark and this mark needs to have a depth of only a fraction of a thousandth of an inch to be very plainly visible. As these marks are caused by conditions which return once for every revolution of the cutter, it is plain that the spacing of the teeth can have no effect on the distance between them and, therefore, on the grade of finish.

32 To test this still further, two cutters of the same size exactly were placed side by side on an arbor. The cutters were ground together so as to be sure they were of equal diameter and they were ground on the arbor so as to be sure that the error would appear simultaneously for both cutters. A block of cast iron was finish-milled with these cutters in such a way that each cutter would sweep half the width of the block. The same number of marks appeared on both sides of the block, and these marks were exactly in line with each other, as might have been expected. The grade of finish was the same for both sides. It was neglected to mark the two sides of

the casting to show which cutter was operating. After this test, all of the teeth but one of one of the two cutters were ground lower, so as to be out of action entirely, leaving only one tooth of the one cutter operative. Another cut like the first one was taken over the same block, and again the finish appeared the same on both sides. There

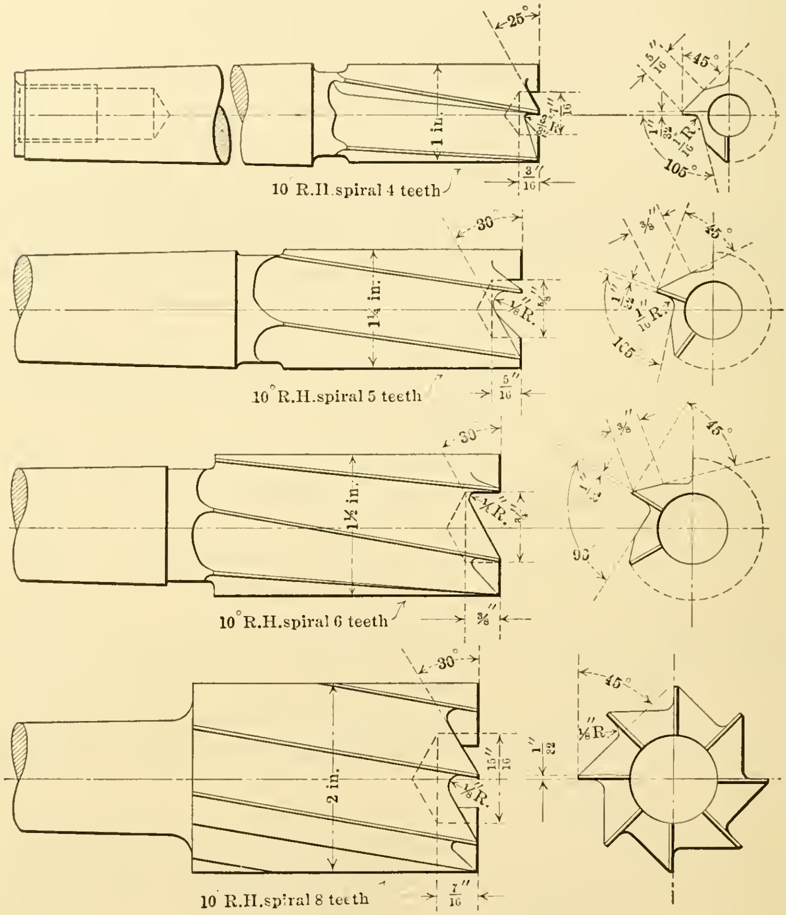


Fig. 11 New Type of Taper Shank End Mills

was a difference of opinion between different observers as to which side was cut by the single tooth. By close observation, however, a difference could be detected when light fell on the work in a certain direction, under which conditions one side showed more gloss than

the other. Straightness, flatness and smoothness to the touch were exactly the same for both sides, notwithstanding that one cutter had one tooth only and the other fourteen teeth. Though it is not recommended here to use cutters with one tooth only for finishing, the foregoing test shows plainly that there is no merit in fine spacing. Attention is again called to the fact, that even though the finish on a single piece *might* be better with more teeth in action, the *average* finish for an entire lot of pieces is better with less teeth.

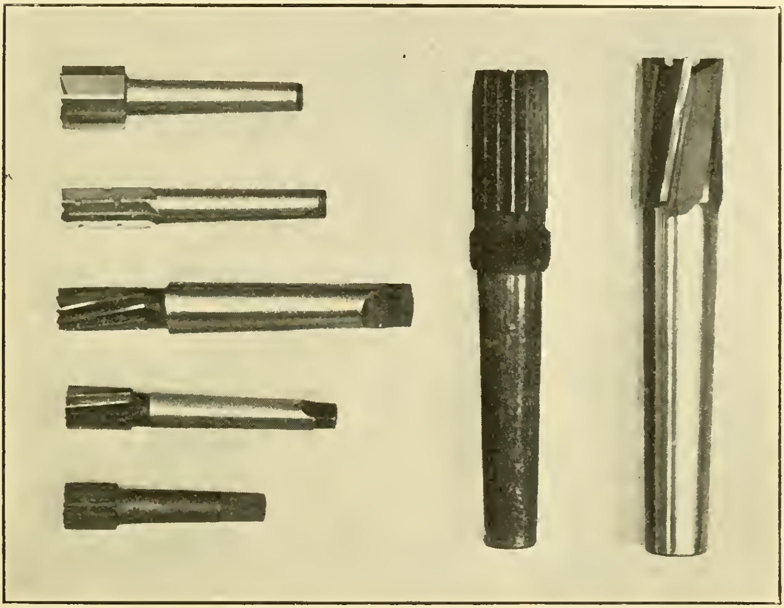


Fig. 12 Comparison of Old Style and New Style End Mills

33 Figs. 11 and 12 show the end mills which are now considered standard by the Cincinnati Milling Machine Company and which fill practically all requirements. They are made in sizes of 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in. and 2 in. in diameter, the smallest with four, and the largest with eight teeth. It will be noticed that in order to preserve the strength of the teeth it is necessary to mill the back of the teeth of the three smaller sizes with two faces. A number of tests have been made with these cutters, but no comparative tests as to power consumption. Their action is remarkably free. This was clearly demonstrated by the following experiment: A 2-in. taper shank end-

mill milled a slot $1\frac{1}{16}$ in. deep in a solid block of cast iron at a rate of 6 in. per min. The block was clamped to the table of the milling machine and the knee was fed upward. Under these conditions the

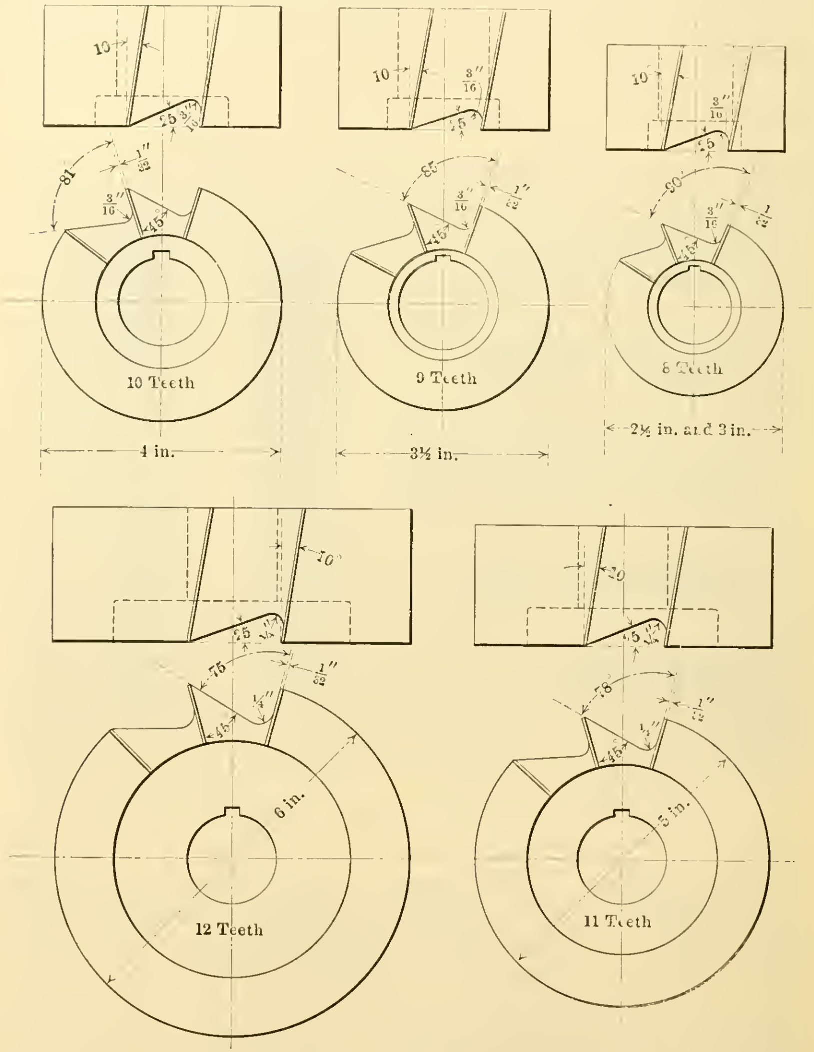


FIG. 13 NEW TYPE OF SPIRAL SHELL CUTTERS

chips did not free themselves from the cutter, but were carried around and ground up. The cutter was cutting over half its circumference. These two conditions combined make the task for the milling cutter

about as difficult as is imaginable. There was, however, no sign of choking and the power consumption was not higher than it would have been with a spiral mill under ordinary conditions. The same cutter would remove from the end of the casting a section $1\frac{1}{2}$ in. wide

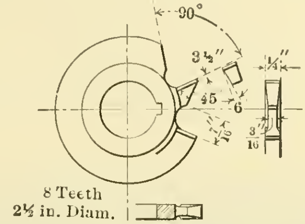


Fig. 14*a* Details of New Type of Side Mills

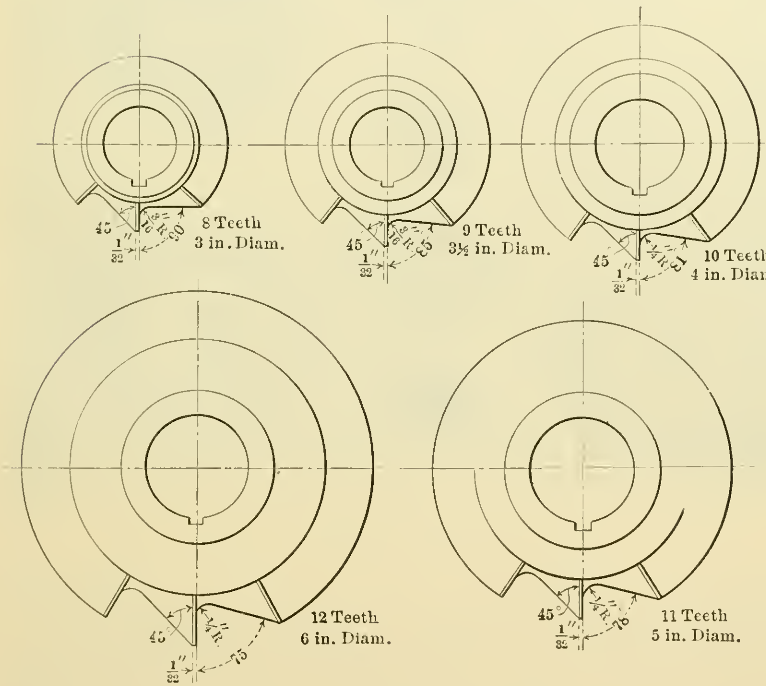


Fig. 14*b* New Type of Side Mills

and $1\frac{1}{2}$ in. deep. Under those conditions, the chips would free themselves from the cutter and these chips were rolled up in pieces much like the chips obtained from a broad planer tool, when taking a finish-

ing cut. This cut was taken with a feed of 11 in. per minute. Another similar cut, but 1 in. and $1\frac{1}{8}$ in. in section was taken with a feed of 33 in. per minute. Similar, though much lighter cuts were taken with ordinary end mills, and in the same piece of cast iron. Again the cast iron seemed to be very bard, and became glossy when cut with an ordinary cutter, but appeared to be soft when cut with the wide-spaced cutter.

34 Fig. 13 shows the shell end mills of the wide-spaced type, which are now considered standard for their use by the Cincinnati Milling Machine Company.

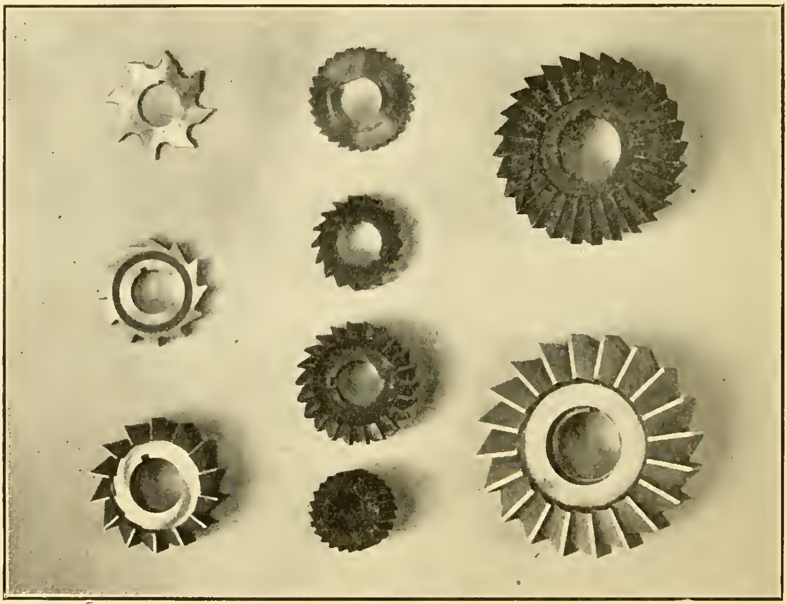


FIG. 15 COMPARISON OF SIDE MILLS AND SLOTTING MILLS

35 Figs. 14*a* and 14*b* show the side mills and Fig. 15 gives a comparison of the new and old-style side mills and slotting mills.

36 Face mills have also undergone a gradual evolution and they are now used by the company and catalogued, though not made by them for use of customers, as shown in Fig. 16. Fig. 17 shows a cutter of a design now generally considered to be standard. In this latter design, the blades are spaced 1 in. apart, or approximately so; they are set radial, and have no means to keep them from pushing back except the regular holding means. The wide-spaced face mill, on the other

hand, has the blades spaced 2 in. apart. They are set at an angle of 15 deg. with the radial line, and are backed by a backing ring with a set screw for each blade. These set screws allow the blade to be adjusted, besides forming a stop against upward movement under pressure. A face mill may be considered as a planing tool moving in a circular path. The cutting edge, therefore, is axial and not radial. To set the blades at an angle with the axis does not produce rake. The wide-spaced face mill shown here has rake, because the blades are set at an angle with the radial line.

37 It will be noticed that the blades are set at an angle with the axis. It will further be noticed, in the enlarged view of the blades, showing the rounded corners, that the corners are not provided with a round, but rather with three faces, which together approximate a curve. It is to offset the effect of this round that the angle with the axis is introduced. In Fig. 18 a new-type face mill is shown at the left and at the right a mill of the old or regular type.

38 However accurately a milling machine may be built, the spindle is not exactly at right angles with the table. The amount of variation from the right angle is very small in a properly built machine, but some variation exists. Besides, this variation is liable to become greater when the machine wears. The result is, that when feeding in one direction the leading teeth of the cutter dig deeper into the work, leaving the other side of the cutter entirely clear, but when feeding in the opposite direction the opposite takes place, which makes the teeth drag over the work. In order to provide the teeth with clearance, the back end of the tooth is ground away at an angle of three to five degrees.

39 It will further be noticed, that there is a land of $\frac{3}{16}$ in. only where the blade is straight. It is the excess of width of the cutting blades which is liable to cause chatter. Strange as it may seem, this chatter is more pronounced with a light than with a heavy cut. It is not meant that there is actually chatter, but merely that when there is a tendency to chatter, the tendency is greater on a lighter cut. The cause is that the tooth does not enter the work but tries to ride over it. When the cutter has been lifted sufficiently, the pressure becomes great enough to make the blades enter. The next blade meets the same difficulty about entering, is lifted again, and so on. This action causes a series of radial chatter marks and is very much worse with wide blades than with narrow ones; and again very much worse with a large number of blades than with a few. A $\frac{3}{16}$-in. land proved to be an acceptable compromise, as a wider land would quickly

No. of Mach	A	B	C	E	D and Thread
2	$2\frac{9}{16}$	$2\frac{15}{64}$	$\frac{1}{2}$	$\frac{3}{4}$	$2\frac{1}{2}$"-4-$\frac{1}{4}$"P-5 Thds. $1\frac{1}{4}$" Lead U.S.S. Shape
3	$3\frac{5}{16}$	$2\frac{57}{64}$	$\frac{1}{2}$	$\frac{3}{4}$	$3\frac{1}{4}$"-3-$\frac{1}{3}$"P-5 Thds 1.66" Lead U.S.S. Shape
4	$4\frac{1}{16}$	$3\frac{9}{16}$	$\frac{5}{8}$	$\frac{1}{2}$	4"-4"P'-5 Thds 2" Lead U.S.S. Shape
5	$4\frac{5}{16}$	$3\frac{13}{16}$	$\frac{5}{8}$	$\frac{1}{2}$	$4\frac{1}{4}$"-4"P'-5 Thds 2" Lead U.S.S. Shape

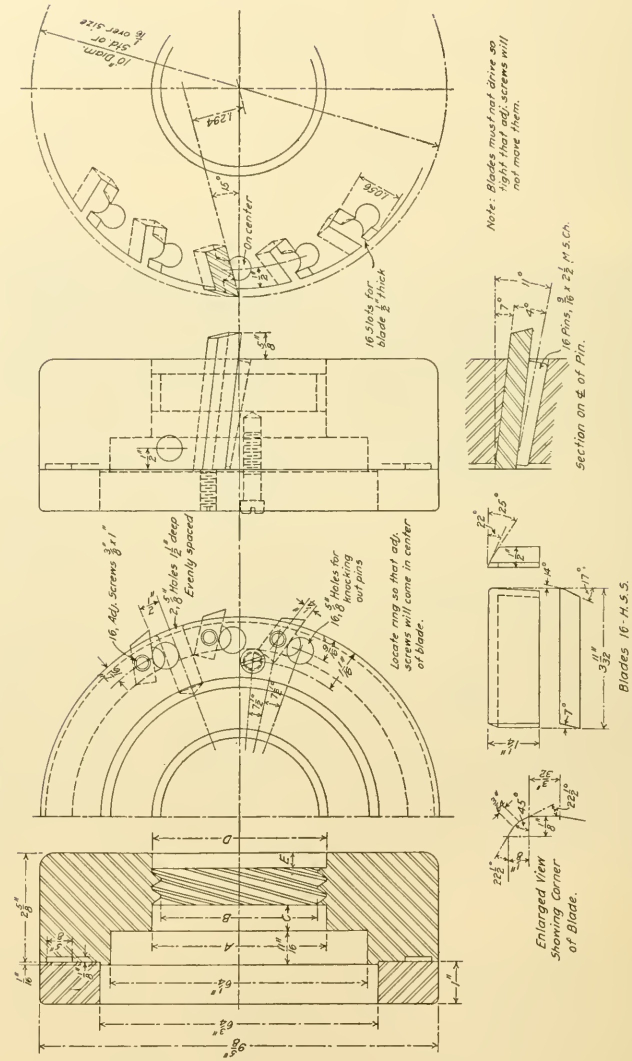
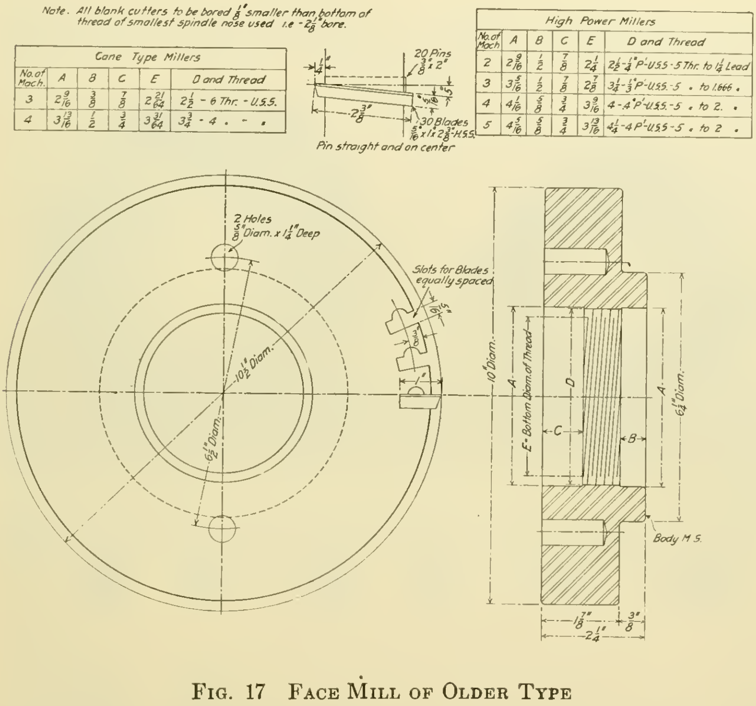


FIG. 16 TEN-INCH BLADE FACE MILL FOR HIGH-POWER MACHINES

dull the cutter, even if it did not make a chatter mark, while a narrower land would have the tendency to produce a scratchy finish.

40 In Fig. 19 is shown details of a helical cutter. These cutters consist of a cylindrical body, with two or three screw threads wound around them, the threads being of a section clearly indicated in the engraving. The helix is wound around the body with an angle of 69 deg. with the axis. The diameter is $3\frac{1}{2}$ in. and the lead of the helix $4\frac{1}{4}$ in. They are made in two styles, either single, or as interlocking right and left hand cutters. They are made with a rake of 15 deg.



Cone Type Millers					
No. of Mach.	A	B	C	E	D and Thread
3	$2\frac{9}{16}$	$\frac{3}{8}$	$\frac{7}{8}$	$2\frac{21}{64}$	$2\frac{1}{2}$ - 6 Thr. - U.S.S.
4	$3\frac{13}{16}$	$\frac{1}{2}$	$\frac{3}{4}$	$3\frac{31}{64}$	$3\frac{3}{4}$ - 4 " - "

High Power Millers					
No. of Mach.	A	B	C	E	D and Thread
2	$2\frac{9}{16}$	$\frac{1}{2}$	$\frac{7}{8}$	$2\frac{1}{4}$	$2\frac{1}{2}$-$\frac{1}{4}$" P'-U.S.S.-5 Thr. to $1\frac{1}{4}$ Lead
3	$3\frac{5}{16}$	$\frac{1}{2}$	$\frac{7}{8}$	$2\frac{7}{8}$	$3\frac{1}{4}$-$\frac{1}{3}$" P'-U.S.S.-5 " to 1.666 "
4	$4\frac{1}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$3\frac{9}{16}$	4-.4" P'-U.S.S.-5 " to 2. "
5	$4\frac{5}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$3\frac{13}{16}$	$4\frac{1}{4}$-4 P'-U.S.S.-5 " to 2 "

Fig. 17 Face Mill of Older Type

and clearance of 5 deg. when used for steel, and with a rake of 8 deg. and clearance of 7 deg. when used for cast iron. Their most distinguishing feature is, that they push the chip off in the direction of the axis of the cutter, or at right angles to the feed. The power consumption is extremely low for steel, but does not show up so favorably for cast iron. A roughing cut in steel requires only about one-third the power of an old-style spiral mill. Another distinguishing feature is, that this cutter does not make revolution marks but tooth marks. As

a result, a much coarser feed can be used for finishing. A cutter with three teeth will allow of a finish three times as fast as an ordinary spiral mill. Still another feature of this cutter is the entire absence of spring in the arbor when cutting steel. It is possible to take a finishing cut over a piece of steel, then return the work under the cutter and let the cutter revolve any length of time without producing a mark. Fig. 20 shows how this feature was made use of in the milling of steel test pieces.

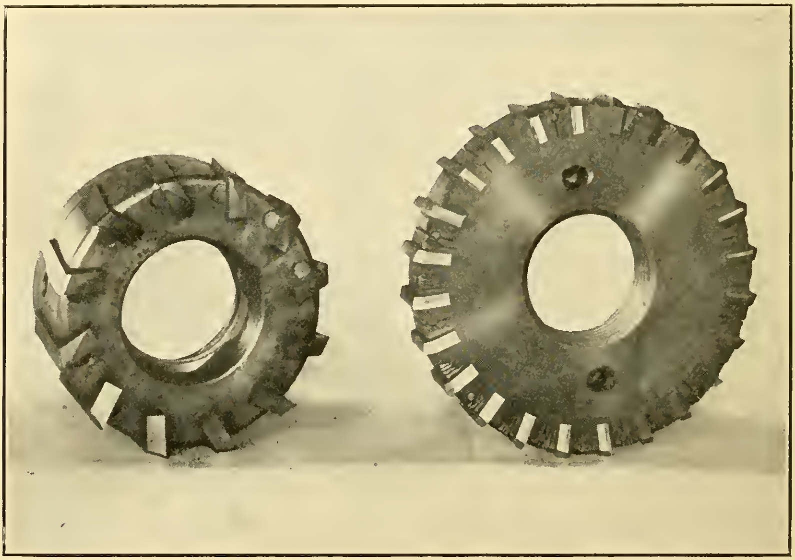


FIG. 18 COMPARISON OF HIGH POWER AND REGULAR FACE MILLS

41 It was originally thought that a single cutter of this description would do well for finishing, but not for roughing, on account of the excessive end pressure on the spindle, and the interlocking cutter was made to obviate this end pressure. However, it was found that this end pressure, though perceptible, was no disturbing element. Cuts which required 80 amperes with the interlocking cutter, required 85 amperes with the single cutter. In order to see if continued use of the single cutter would cause increasing friction at the spindle end, a great number of cuts were taken in as rapid succession as it was possible to adjust the machine for the next cut.

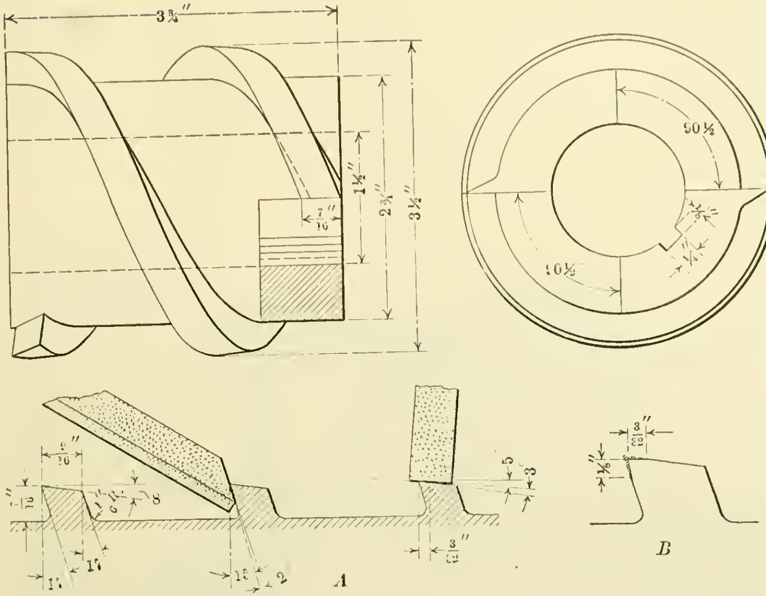


Fig. 19 Details of New Type of Helical Cutter

42 The fact that there is no spring in the arbor makes it possible to use the milling machine without braces in a great many cases where they would otherwise be needed.

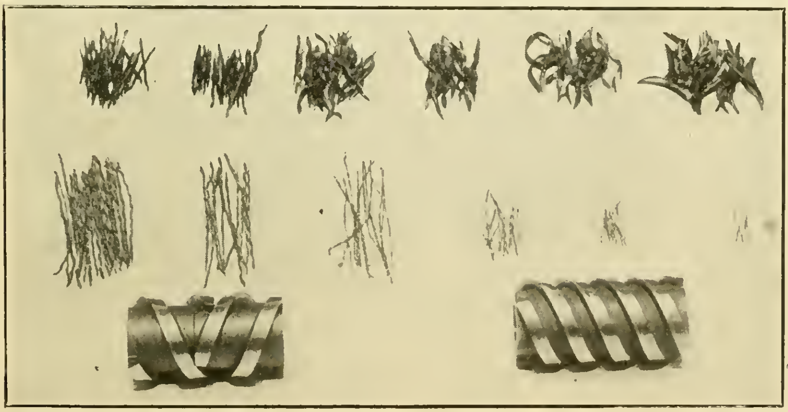


Fig. 20 Helical Cutters, Single and Interlocked, and Chips Produced by Them

43 The chips come from the work in the form of gimlets as shown in Fig. 20. The back of the chip is polished or burnished, and a surface of the work shows no sign of tearing of the metal.

44 It was first believed that these cutters would work best at a high speed; but it was found that this was not the case. They produce the best results when run at the same number of revolutions as the ordinary spiral mill.

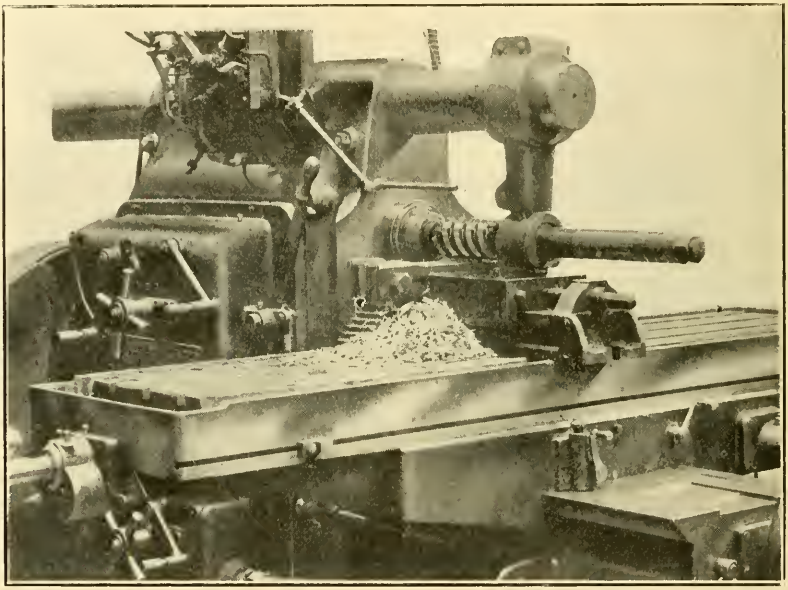


Fig. 21 Helical Cutter at Work on Steel Test Pieces

45 The writer believes that the remarkably low-power consumption is due to what might be called "virtual rake," which is an angle depending on the angle of rake, and on the angle the thread or tooth makes with the axis. This virtual rake becomes a small angle when the actual rake is small. This is the case with the cutter as used for steel, where the actual rake is 75 deg. Where, however, the angle of rake approaches 90 deg., the influence of the helix becomes very much less pronounced; and, if the actual rake were 90 deg., the influence of the spirality would be zero; in other words, the virtual would equal the actual rake. This may explain why the saving in power consumption is not so pronounced when cutting cast iron. It is believed that this saving of power would be equally great with cast

iron as with steel, if the same virtual rake could be obtained, and this supposition was borne out by a few tests made on cast iron with a helical cutter ground for steel. The fact, however, that the edge of the cutter would not stand up, made it impossible to extend the tests far enough to come to a safe conclusion.

46 Another reason which suggests itself to the writer, as to why the helical cutter shows less saving in power on cast iron than on steel, is the result of a series of tests made on cast iron and steel with spiral mills with and without rake, the rake being in all cases 9 deg. These cutters showed improved efficiency for steel and cast iron, but much more for the first than for the latter. A cutting tool must detach the chip from the work, bend the chip and at least partially break it up. When cutting steel, the radius of curvature of the chip becomes greater with increased rake and the extent to which the chip is broken up becomes less. Cast iron will stand much less bending before breaking, so that, even with increased rake, the chip is still broken up as before, and no saving in power can be effected in this part of the process.

47 Figs. 22 and 23 are diagrams comparing the performance of different styles of cutters for different materials and the different depths of cut. Fig. 22 gives a comparison with feeds of 4 in. per minute and Fig. 23 for 14 in. per minute. It will be noticed that all lines are practically straight with the exception of the line for the regular face mill when cutting machinery steel. This line makes a sharp turn. This is believed to be due to the fact that the blades of this face mill did not project far enough beyond the body. As cast iron chips were crumbled up the effect was not noticeable for cast iron, but became quite important for machine steel. Fig. 22 shows that for cutting cast iron the high-power face mill is the most efficient. Then comes the regular face mill, then the spiral mill with $1\frac{1}{8}$-in. spacing, then the spiral mill with $\frac{3}{4}$-in., then the spiral mill with $\frac{5}{8}$-in. spacing. The 5-in. and 3-in. end mills come last in efficiency. These mills are of the old type with relatively fine spacing.

48 The order of efficiency of the different cutters is somewhat different for machine steel. The helical mill comes first, then the high-power face mill, then the spiral mill with $\frac{3}{4}$-in. spacing (no tests were made with spiral mills with $\frac{5}{8}$-in. and $1\frac{1}{8}$-in. spacing on machine steel) and finally the regular face mill; but it should be noticed that, if the curve for this mill had continued the way it started, it would have been below the curve for a spiral mill.

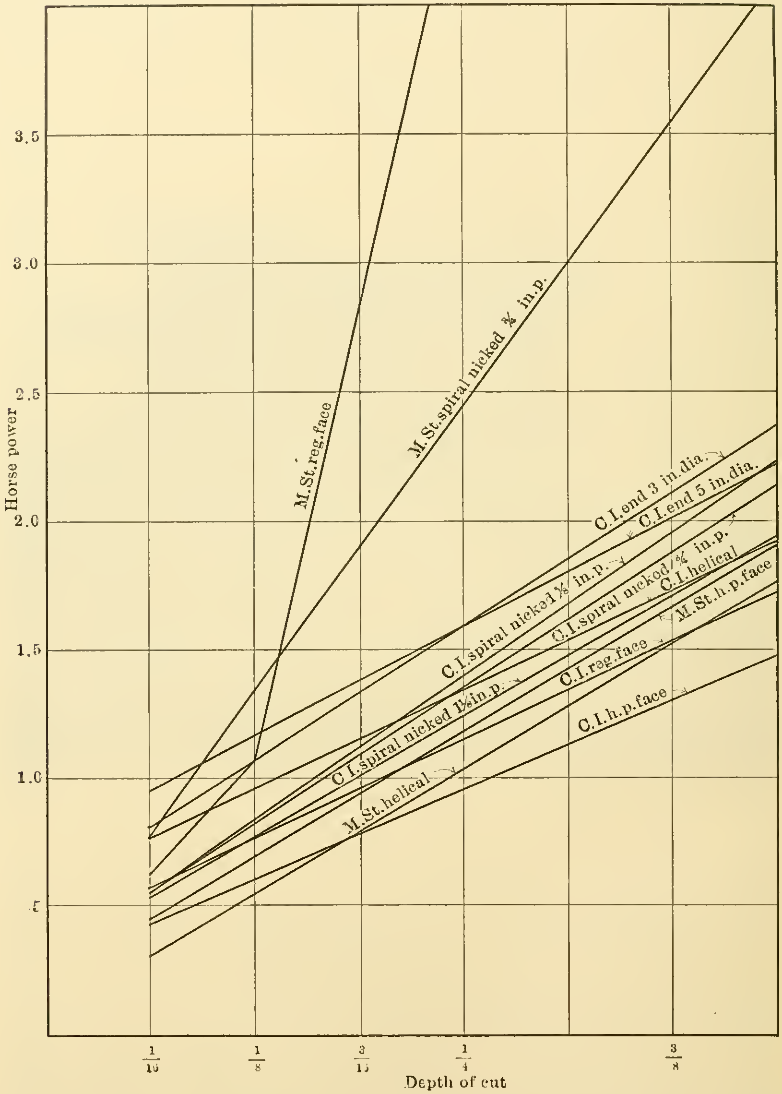


FIG. 22 EFFICIENCY TESTS OF CUTTERS. COMPARISONS CURVE REDUCED TO 1 IN. WIDTH OF CUT. CAST-IRON CURVES CORRECTED FOR HARDNESS OF MATERIAL. FEED 4 IN. PER MIN.

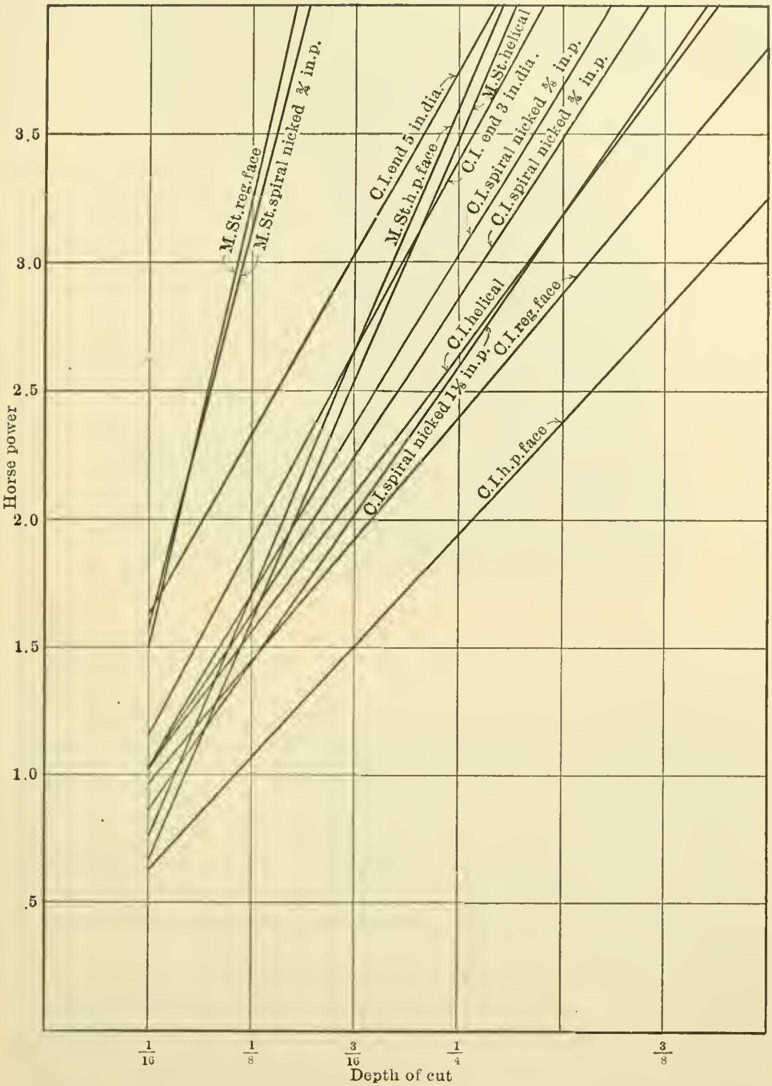


Fig. 23 Efficiency Tests of Cutters. Comparison Curves reduced to 1 in. Width of Cut. Cast-Iron Curves Corrected for Hardness of Material. Feed 14 in. per Min.

49 Fig. 23 gives comparative curves for a feed of 14 in. per min. The order of efficiency is much the same as in Fig. 23 with some exceptions. The helical mill, for instance, becomes more and more efficient as the heavier cuts are taken.

APPENDIX

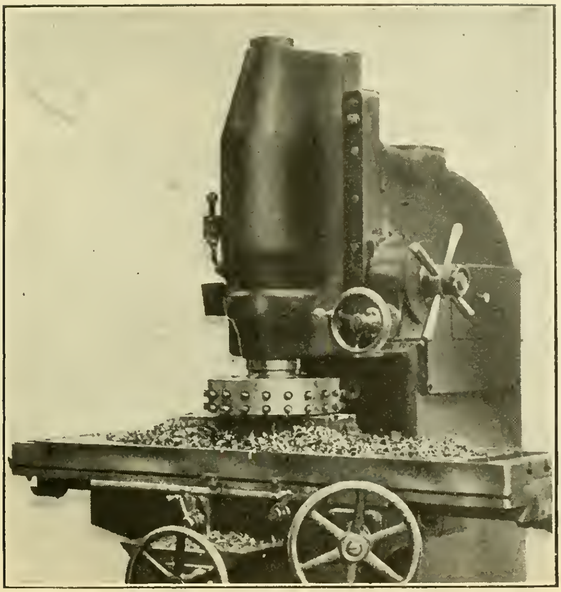


Fig. 24 High-Power Face Mill of Early Construction, Milling Machine-Steel Test Blocks. Chips Resemble Planer Chips

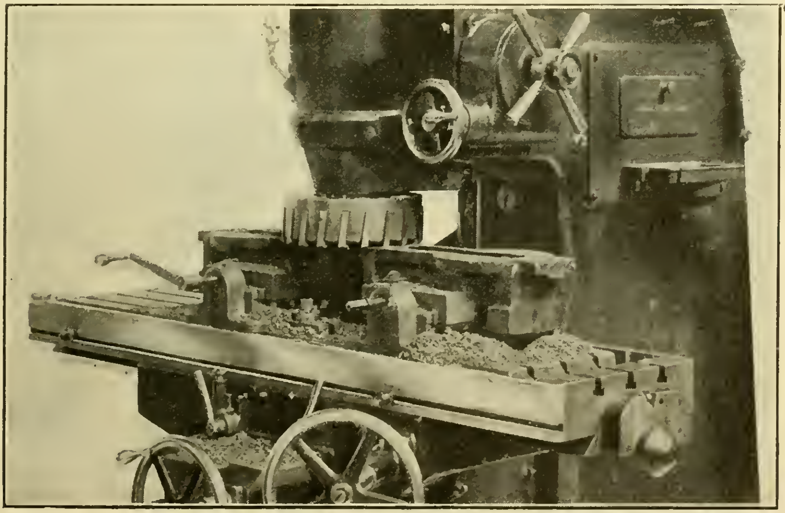


Fig. 25 High-power Face Mill Roughing Bottoms of Vise Bodies. One Piece is Chucked while the other is Milling

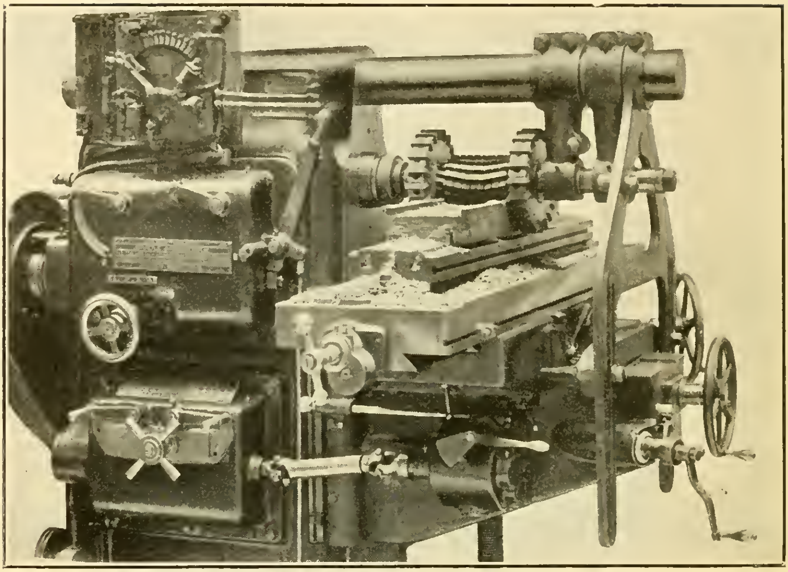


Fig. 26 Wide-Space Gang Roughing Vise Housings

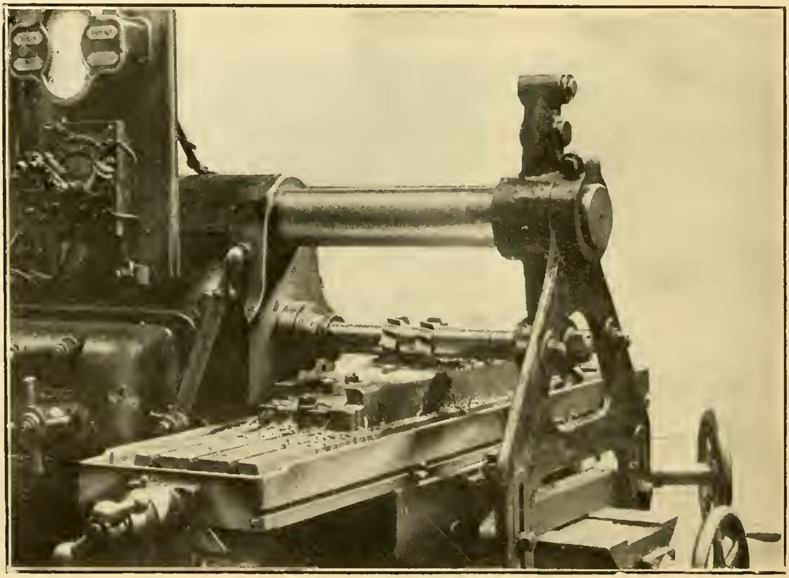


Fig. 27 New Style Gang at Work on Steel

FIG. 28 EFFICIENCY CURVES SHOWN IN FIG. 6 REDUCED TO 1 IN. WIDTH OF CUT

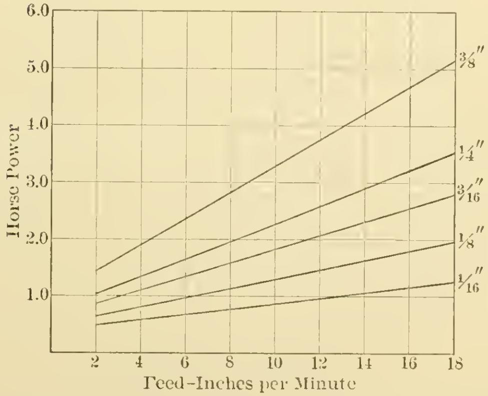


FIG. 29 EFFICIENCY CURVES SHOWN IN FIG. 7 REDUCED TO 1 IN. WIDTH OF CUT

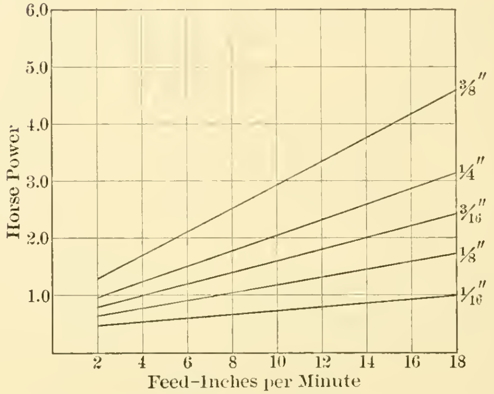


FIG. 30 EFFICIENCY CURVES SHOWN IN FIG. 8 REDUCED TO 1 IN. WIDTH OF CUT

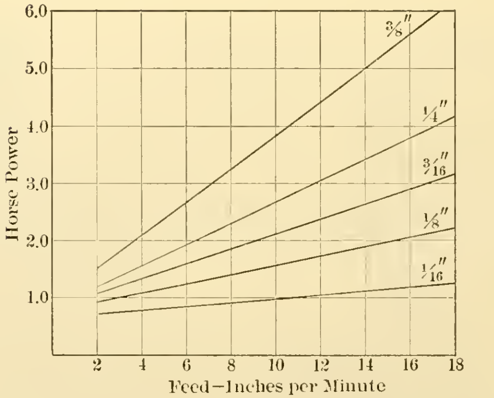


FIG. 31 TESTS OF END MILLING-CUTTER 3 IN. DIAMETER, 14 TEETH. CUTTING CAST IRON, CORRECTED FOR HARDNESS. WIDTH OF CUT $2\frac{7}{8}$ IN. REDUCED TO BASIS OF 1 IN.

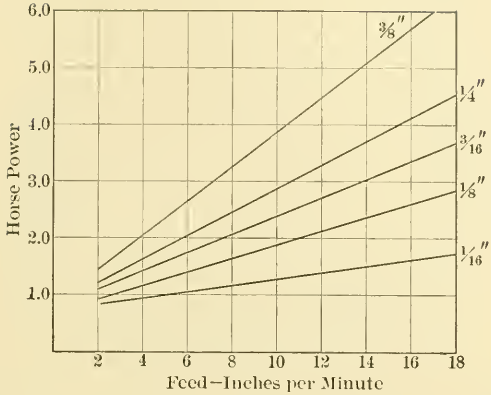


Fig. 32 Tests of End Milling-Cutter 5 in. Diameter, 20 Teeth. Cutting Cast Iron, Corrected for Hardness. Width of Cut 3 in., Reduced to Basis of 1 in.

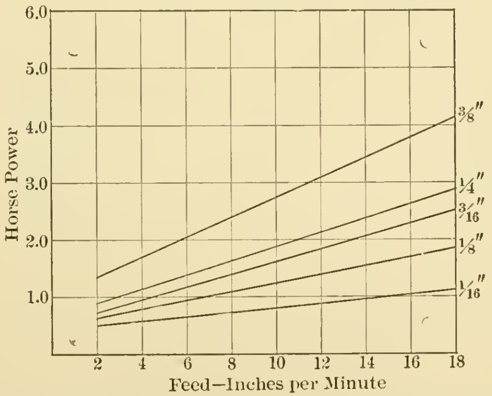


Fig. 33 Tests of Regular Face Milling-Cutter $9\frac{1}{2}$ in. Diameter, 22 Teeth. Cutting Cast Iron, Corrected for Hardness. Width of Cut 6 in., Reduced to Basis of 1 in.

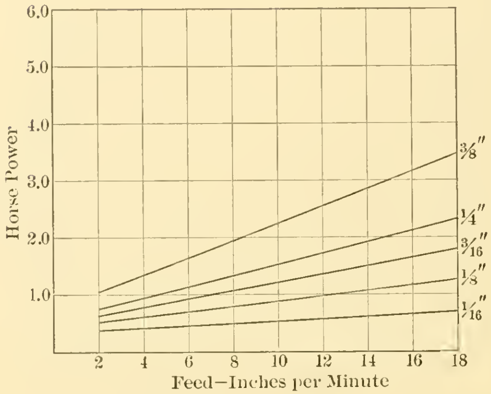


Fig. 34 Tests of High-Power Face Milling-Cutter 8 in. Diameter, 6 in. Teeth. Cutting Cast Iron, Corrected for Hardness. Width of Cut 12 in. Reduced to Basis of 1 in.

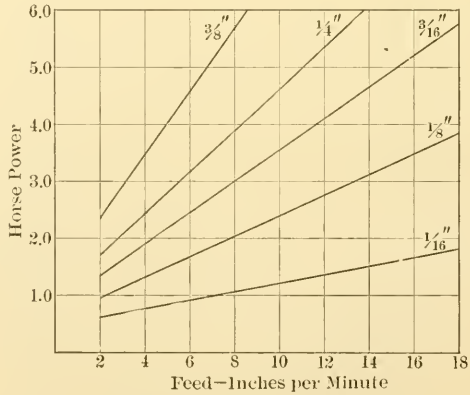


Fig. 35 Tests of Spiral Nicked Milling Cutter $3\frac{1}{2}$ in. Diameter, 14 Teeth, and about $\frac{3}{4}$ in. Pitch. Cutting Machine Steel: 0.50 Manganese, 0.20 Carbon, 55,000 lb. Tensile Strength. Width of Cut 6 in., Reduced to Basis of 1 in.

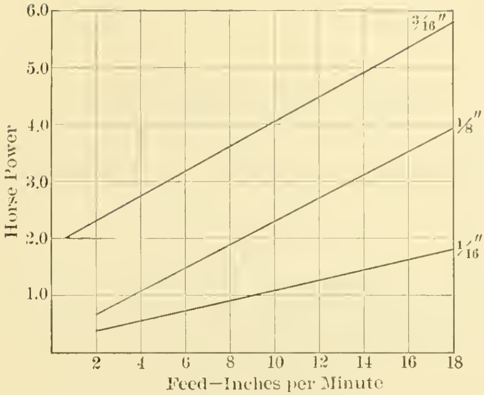


FIG. 36 TESTS OF REGULAR FACE MILLING-CUTTER $9\frac{1}{2}$ IN. DIAMETER, 22 TEETH. CUTTING MACHINE STEEL; 0.50 MANGANESE, 0.20 CARBON, 55,000 LB. TENSILE STRENGTH. WIDTH OF CUT 6 IN., REDUCED TO BASIS OF 1 IN.

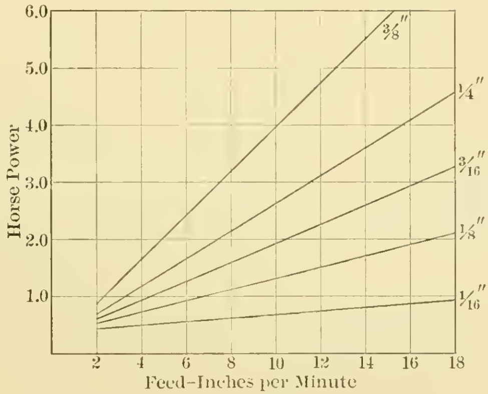


FIG. 37 TESTS OF HIGH-POWER FACE MILLING-CUTTER 8 IN. DIAMETER, 12 TEETH. CUTTING MACHINE STEEL: 0.50 MANGANESE, 0.20 CARBON, 55,000 LB. TENSILE STRENGTH. WIDTH OF CUT 6 IN., REDUCED TO BASIS OF 1 IN.

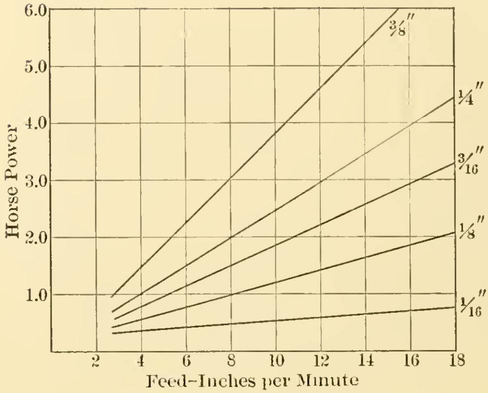


Fig. 38 Tests of Helical Milling-Cutter $3\frac{1}{2}$ in. Diameter, $4\frac{1}{4}$ in. Lead, $2\frac{1}{8}$ in. Pitch. Cutting Machine Steel: 0.50 Manganese, 0.20 Carbon, 55,000 lb. Tensile Strength. Width of Cut $5\frac{1}{2}$ in., Reduced to Basis of 1 in.

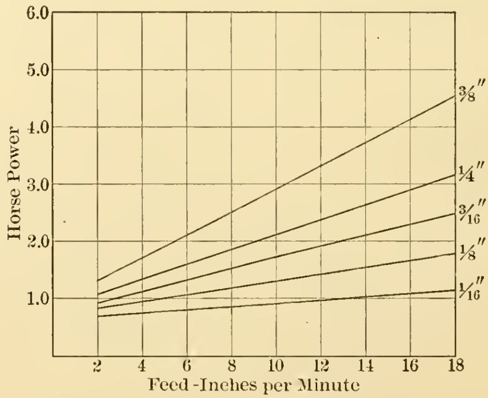


Fig. 39 Tests of Helical Milling-Cutter $3\frac{7}{16}$ in. Diameter, $4\frac{1}{4}$ in. Lead, $\frac{15}{16}$ in. Pitch. Cutting Cast Iron, Corrected for Hardness. Width of Cut 6 in., Reduced to Basis of 1 in.

THE ROTARY KILN

By Ellis Soper, Published in The Journal for October 1910

ABSTRACT OF PAPER

The paper gives a brief history of the development of the rotary kiln and commercially successful applications of it. A drawing is shown of a typical installation of an 8 ft. by 125 ft. kiln for burning cement by the dry process. The temperature curves are for a 7 ft. by 100 ft. kiln and there are three curves showing chemical changes in kilns of various sizes. There is also a table of kiln sizes, outputs and fuel consumptions with relation of the diameter to the length and the actual results from lengthening a 6 ft. by 60 ft. kiln. The heat balance, calculation of mixture, etc., is given for an 8 ft. by 125 ft. kiln operating upon lime rock and shale, using the dry process; also curves showing stresses in shell due to the improper spacing of tires, the fallacy of supporting upon more than two tires and the proper spacing of tires when the weakening effect of heat is considered. A fuel consumption curve illustrating the law of pivotal points, size of kiln conditions remaining constant, and output in barrels per day at which the fuel consumption is a minimum are stated.

DISCUSSION

Richard K. Meade.[1] Mr. Soper in Par. 3 of his paper states that pulverized coal was first tried as a fuel at the Atlas mill. I believe that this is a very much mooted question; one indeed, which even the courts have been asked to decide and which to date has never been settled.

Mr. Edison certainly deserves great credit and also the commendation of cement manufacturers for his courage and ingenuity in building the long cement kiln. The writer was with Mr. Edison at the time these kilns were installed and had many arguments with others in the cement industry as to their practicability. The contentions of all manufacturers at that time seemed to be that these

[1] Meade Testing Laboratories, Allentown, Pa.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

long kilns would overburn the cement and that the resulting product would be lacking, if indeed not entirely deficient, in hydraulic properties. The writer undertook to disprove this and succeeded in doing so by fusing portland cement in an electric furnace. The resulting clinker was found to have excellent hydraulic properties and to compare favorably with the product of the shorter 60-ft. kiln, then universally employed. As a matter of fact, when the long kilns were started, they burned clinker which was in every way similar to that burned by the short 60-ft. kilns and in no way different from it in point of vitrification, appearance or hydraulic properties.

Three variables enter into the production of portland cement clinker; namely, the temperature of burning, length of time in the kiln and the degree of fineness to which the raw materials have been reduced. This may be expressed mathematically as an equation: $A + B + C = D$, in which A represents time, B temperature, C fineness and D a constant, namely, clinker. If any one of the three variables, A, B or C is increased, one or both of the other two will be decreased. By increasing the time in the kiln, the temperature necessary to clinker is decreased, while if the materials are ground more finely, either the temperature or the length of time in the kiln is decreased, and thus the output of the kiln may be increased and the fuel required per barrel decreased. With a long kiln the time in the kiln is simply increased, and I believe our long kilns are all working at a lower temperature than the old 60-ft. kilns employed. Measurements of the temperature of both show that the long kilns work at a lower temperature. The time of the material in the kiln may be shortened or lengthened by the speed at which the kiln is revolved. The long kilns may generally be considered to revolve at a more rapid speed than the shorter ones. The inclination of the kiln from the horizontal has also much to do with the time of the material in the kiln.

Mr. Soper brings up one very interesting point for discussion, namely, whether it is better to install one large kiln having a capacity of say 2000 bbl. per day or four smaller kilns which would produce the same output. A kiln with this very large capacity is of course an experiment, and has been tried only at one large plant in this country where several kilns are employed. The size of the kiln to be installed would seem to the writer, so far as its diameter and capacity are concerned, to depend upon the total production of the contemplated plant and in no plant should a kiln having a capacity larger than 25 per cent of the total capacity of the plant be installed, for the reason that when

the kiln is shut down the whole plant must be shut down. When this occurs, fixed charges go on and the cost of production is consequently increased. One point that all cement engineers are striving for is to design a plant in which shut-downs will be reduced to a minimum, or at least confined to only a small part of the plant. Shut-downs occur often with the large kilns and it is questioned whether the large units save fuel, or at least save enough to make up for the curtailment of production due to the shutting down of a large part of the plant.

One objection to kilns of very large diameter is the key of the brick. If the diameter of the kiln is much above 9 ft., the key of the brick is so slight that constant trouble with the lining will be encountered, unless this latter is of unusual thickness, which of course greatly decreases the working diameter of the kiln. This difficulty, we understand, has been encountered with the 12-ft. kiln employed at present.

We believe that it would not be a good policy for any new company to install kilns with a capacity of more than 25 per cent of the contemplated output. Concerns, however, which have a large capacity can afford to install for experimental purposes a large kiln of considerably greater proportions than that ordinarily used, but so far a greater economy has been obtained by increasing the length of the kiln.

At the plant of the Allentown Portland Cement Company, one of the most modern cement mills, there are installed today four kilns which have a capacity of from 600 bbl. to 700 bbl. daily. These kilns are 8 ft. in diameter and 120 ft. long. The coal consumption is on an average 80 lb. per bbl. of cement produced. The capacity of these kilns, however, owes some of its increase over other kilns of the same or even greater size to the fact that both the raw materials and the coal used for burning the latter are pulverized very finely. As already stated, this affects the capacity and the economy of the kiln.

In general it may be stated that the capacity of the kiln is dependent on its diameter, and its economy, so far as fuel is concerned, on its length. That is, if we wish a kiln with a large output merely we would increase the diameter, while if we wish a kiln to be economical we would increase its length. That is, a kiln 6 ft. by 100 ft. will burn cement with less coal than will one 6 ft. by 60 ft. On the other hand, a kiln 7 ft. by 100 ft. will give a greater output than will one 6 ft. by 100 ft. In figuring the output of a kiln the thickness of the lining must always be considered, for a kiln 8 ft. 6 in. in diameter

lined with 9-in. brick will have the same internal diameter and give as much clinker as one 9 ft. in diameter lined with 12-in. bricks.

Kilns 8 ft. by 125 ft. are in operation today at the Great Western Portland Cement Company's plant, which under normal capacity, average from 800 bbl. to 850 bbl. daily. Oil, however, is used as fuel.

In Par. 8, Mr. Soper states that the kilns are lined with magnesia brick. At present the use of this brick is uncommon in the east, where a highly refractory silica brick is almost universally employed. In certain parts of the country a bauxite or alumina brick is employed and at one or two plants bricks made from portland cement clinker and cement are used.

Mr. Soper gives a number of interesting charts, among them two showing the chemical changes in a 6 ft. by 60 ft. and in a 6 ft. by 160 ft. rotary kiln respectively. A comparison of these two charts shows very conclusively the functions performed by the additional length of the kiln. If the dips in the lines of the various compounds are taken out, as they should be, since these dips are due to unavoidable analytical and experimental errors, and the lines are plotted to smooth curves, it will be seen that in the long kilns practically no change takes place for the first 80 ft. other than the driving off of the water. Up to this point practically all of the heat taken up by the materials has been employed in heating them up to the temperature at which dissociation of the carbon dioxide begins (about 1800 deg. fahr.). From this point to 130 ft. from the entrance of the kiln all the heat absorbed by the material is utilized for two purposes, viz: for the dissociation of the carbon dioxide and to heat the material to a temperature necessary to clinker (about 2200 deg. to 2500 deg. fahr.), while in the last 20 ft. of the kiln the clinkering itself takes place. This is supposed to require no heat and to take place as soon as the critical temperature of combination is reached. It is supposed and has been seemingly experimentally demonstrated that heat is given off in clinkering. With the long 160-ft. kiln, therefore, it will be seen that over half the kiln is utilized to heat the material to the point at which dissociation of the carbon dioxide begins, while with the short 60-ft. kiln only about one-quarter or 16 ft. of the length is so used. Consequently, these 16 ft. must be very much hotter in order to do the work of the 90 ft. in the longer kiln, and the gases must therefore leave the kiln at a much higher temperature. The function of the extra length therefore is to use the heat of the gases to warm the incoming material.

Mr. Soper gives an interesting mathematical discussion of the utilization of the heat in the rotary kiln. These heat balances are dependent on so much experimental data which have not been fully established that the writer has never put very much credit in them, although he has very frequently drawn them up himself. Professor Landis of Lehigh University has made a number of these heat balances for various sizes of kilns and it is interesting to compare his results with those obtained by Mr. Soper. A discusssion of the various points brought out by these balances would require a great deal of time, but it may be interesting here to note that Professor Landis believes this heat to be distributed under the best conditions something as follows:

For chemical reactions, such as the decomposition of the carbonates, etc	24.8 per cent
For the chimney loss with perfect combustion and waste gases at 500 deg. cent	21.4 per cent
Clinker loss, that is, heat carried off by clinker	16.6 per cent
Radiation and conduction loss with ordinary lining	37.2 per cent

It will be seen by examining the balances of Mr. Soper and Professor Landis that a large percentage of heat is carried off through the kiln walls and hood by radiation and conduction. It has been proposed to stop this loss by suitable linings, which are poor conductors of heat. One point, however, that must be considered in this connection is that it is necessary to carry the heat away from the lining in order to keep it cool. The principle is exactly the same as the employment of water-cooled bosh plates in a furnace blast. If all the heat were confined to the kiln and the fire brick linings of the latter were not cooled, the bricks in the clinkering zone would be rapidly corroded and eaten away by the strongly basic material burned in the kiln. It is possible, however, that by the substitution of some other form of brick than the ordinary silica brick this could be avoided.

W. S. Landis.[1] Measurements made by myself on the temperature of discharged clinker have shown temperatures of 1830 deg. to 2000 deg. fahr. In no cases have I ever seen temperatures as low as Mr. Soper's, except in the case of an under-cooler being used in connection with the kiln.

Waste gases passing into the stack at 650 deg. fahr. is almost good boiler practice. The lowest temperature I have ever recorded in our

[1]Associate Professor of Metallurgy, Lehigh University, South Bethlehem, Pa.

own country is 900 deg. fahr. and temperatures above 950 deg. are quite common. Abroad, even under the most excellent supervision the stack temperatures in kilns of the size studied by Mr. Soper have been above 950 deg.

In nearly all kilns the draft is regulated by the opening and closing of a door in the base of the stack. It is barely possible that the temperature given was measured in the stack after dilution of the kiln gases with a large amount of cold air through such a door. In that case correction should be made according to the quantity of gases passing out through the stack for this extra air entering it.

The temperature at which CO_2 is liberated from the carbonates in the mix is not 1000 deg. fahr. With only 10 per cent CO_2 in the gases passing over the mix, corresponding to a CO_2 tension of 76 mm. mercury, the equilibrium temperature would be 1200 deg. fahr., and to insure rapid decomposition under operating conditions the temperature must be considerably above that given. Measured values for this temperature made in a running kiln have shown temperatures nearer 1470 deg. fahr.

The heats of combination of CaO, Al_2O_3 and SiO_2 as given in the paper are new to me. If we knew the exact natures of the chemical reactions taking place in the kiln we might use appropriate figures for this calculation, but I do not think this is known. By clinkering the mix used in the Nazareth region in a bomb calorimeter I have evaluated a heat of formation of the clinker (union of CaO, Al_2O_3 and SiO_2) of 360 B.t.u. per lb. of clinker formed, a figure much less than that used by the author. I have further verified my figure by the rise in temperature noted in a very careful study of the operation of a rotary kiln made in Germany and found it to hold within a very few per cent.

In the item of heat carried off by waste gases I note that the author uses as the weight of the waste gases that of the air used in combustion. This is a decided error as these gases contain CO_2 and H_2O, N_2 and excess air, an entirely different material from the air entering the kiln.

In the summary of the heat balance I note another very serious error. In items *b* and *c* the author has calculated the heat put into the mix and clinker. Again in items *d* and *f* he has charged himself with the heat in these same materials; in other words he has charged himself with the heat required to raise them to the required temperature and again with this same heat in them. I was further surprised to see, after this error that he had not somewhere accounted for the heat in the clinker between 1400 and 2500 deg. fahr.

Further I note that the author has charged the heat in the excess air against the calorific power of the coal and again inserted this same heat on the other side of the balance sheet as part of the heat carried out in the waste gases, which are made up of the air used plus this same excess of air.

If the author will remove these twice-counted items from his summary he will not have an unaccounted difference of 16 per cent of the total heat available, particularly if he uses better specific heats and weights of stack gases.

The whole balance sheet could be very much simplified by constructing it as follows:

HEAT AVAILABLE

Sensible heat in mix, coal and moist air used for combustion
Heat of formation of clinker
Heat of combustion of fuel

HEAT DISTRIBUTION

Heat carried out in stack gases
Heat carried out in hot clinker
Heat required to decompose carbonates
Heat lost by incomplete combustion (if existing)
Heat lost by radiation and conduction

I have published a number of balance sheets based on this form in the Cement Record.[1] It is not possible to reconstruct the balance sheet given above along this line without a great deal of trouble, because of lack of sufficient data.

E. A. W. Jeffries. I will not venture to discuss any of the statements made by the author, but will call attention to a point of some importance with reference to the method of firing rotary kilns which Mr. Soper did not discuss. In his opening paragraph the remarkable statement is made that the burning cost represents from one-third to one-half the total cost of manufacture of a barrel of portland cement. In his summary of the heat distribution (Par. 12), Mr. Soper shows that less than 45 per cent of the heat delivered by the fuel does effective work and this figure is undoubtedly above the average found in practice. Part of this loss is unavoidable because there must be some radiation and there must be some heat carried away by the stack. There is no doubt, however, that

[1]Cement Record, Vol. 2, September 1909 and Vol. 3, February 1910.

the large proportionate cost above mentioned can be greatly reduced when cement manufacturers get ready to take up earnestly and intelligently the problem of properly applying producer gas to their business. There have been many abortive attempts, but never to my knowledge a thorough one. One reason for this is that it has been only recently that a really good gas producer adequate for this severe service has been available. Such a producer is now well developed and well tested.

The advantages of this method are: first, in making a large variety of cheaper coals available for this service which will not give satisfactory results in the pulverized state; second, when gas is burned there is no occasion for using a surplus of air, since a temperature sufficiently high can be maintained, without the loss from this source, whereas with pulverized coal at least 50 per cent excess air must be used to insure perfect combustion, which is even then difficult to maintain; third, the running expense for labor, wear and tear is very much less in a good gas plant than in a coal-drying, pulverizing and conveying equipment.

R. C. Carpenter. The paper presented by Mr. Soper is one of great interest to cement engineers. They will all, I am sure, agree with Mr. Soper in respect to the improvements which he mentions as having been produced by the installation of the large kilns in place of the small ones. Engineers who are familiar with the art also realize the truth of the statement which he makes in Par. 3 and in which he states, in effect, that Mr. Edison was laughed at when he installed rotary kilns 9 ft. in diameter by 150 ft. in length. They will also agree with him that the installation of these large kilns, for which we must thank Mr. Edison, is the most important advance step in the history of the industry from the engineering standpoint. It is my opinion from a careful study of the industry that Mr. Edison not only discovered the advantage of employing large kilns, but that he also developed a new principle of operation which applies to such kilns. It is due as much to the application of this principle as it is to the use of large kilns that the great improvements to which Mr. Soper refers have been brought about.

Several statements in the paper seem to be in error, or at least to disagree with my experience and observation. One statement to which I would call attention is the fuel consumption of the 60-ft. kilns. In Par. 11 for instance, the author states that a 6 ft. by 60 ft. kiln has an output of 140 bbl. per day and a fuel consumption

of 240 lb. per bbl. The fuel consumption referred to is, it seems to me, extreme even for such wet materials as were employed when marl and clay were taken as the raw cement materials. For dry materials the consumption is certainly much less. In Table 1 I note that he gives as the coal consumption of normal 60-ft. kilns 6 ft. in diameter, 140 lb. to 160 lb. of coal per bbl. This doubtless refers to the burning of dry material. That fuel consumption, in my opinion, is somewhat large even for that size of kiln. My own experience indicates that the coal consumption of the 6 ft. by 60 ft. kiln averaged perhaps 110 lb. per bbl. with dry material and varied from 125 lb. to something approaching 100 lb. under the most efficient conditions. The output of these kilns was also somewhat greater than stated in the paper, which mentions 175 bbl. per day as the output. My experience indicated that the 6 ft. by 60 ft. kilns sometimes gave an output of 200 bbl. or even 225 bbl. per day under favorable conditions. It may be, however, that Mr. Soper's figures in Par. 11 are fairly comparative and the figures given at the end of the paragraph may be of interest as showing actual comparative results on similar wet materials.

The heat balance which is given in connection with the paper is an interesting one. There is in my opinion, however, quite a serious mistake in calculating the amount of heat carried off by the waste gases. The paper assumes that only 8 lb. of air are theoretically required to burn 1 lb. of coal, whereas about 50 per cent more than that is theoretically required for pure carbon. This will not differ much from what is required for coals containing a considerable amount of volatile matter, as is the case with most coals employed in rotary kiln practice. This error is neutralized to some extent by the assumption that one and one-half times the theoretical air supply is used, although even this assumption does not allow for the considerable percentage of excess air which must be used in rotary kilns. Making this correction in the summary of his results, the losses accounted for by the waste gases will be increased considerably and the calculation made more reasonable.

Another assumption made in the paper which I think is far from the truth, is regarding the temperature of the gases leaving the kiln. This temperature is assumed to be 650 deg. fahr., an amount not greatly in excess of what we find in the stacks of boilers when they are heavily pushed. I have personally measured the temperature at the bottom of the stacks in several instances and have never found it as low as Mr. Soper indicates. My own experience is that if the

kilns are operated at economical capacity the temperature of the kiln gases at the base of the stack will not fall below 1000 deg. I do not believe that a lower stack temperature indicates economical operation, considering the output with reference to the expenditure and overhead charges. If this correction is made to the heat balance it will roughly indicate that the stack losses are about 15 per cent instead of 10 per cent and the radiation losses about 12 per cent instead of 16 per cent, both of which results are somewhat more reasonable than those given. I doubt that under good conditions of operation the stack loss should fall under 30 per cent.

It should be noted that the heat distribution given in the paper is open to some question because it is obtained by calculations made from assumed conditions. Some of the assumed conditions do not seem to be very reasonable; for instance, he assumes that the average temperature of the kiln shell is about 450 deg. fahr. and the average temperature of the surrounding air 70 deg. I have no data as to the temperature of the kiln shell, but I have been in a number of kiln rooms and I never yet had the good fortune to be in one in which the average temperature of the air was as low as 70 deg. It usually is much higher, especially in the neighborhood of the kiln. These various corrections will not, however, greatly change the results.

It may be mentioned that the heat which is stated to be liberated by chemical reaction is due to the heat of combination of the various silicates of the cement clinker. This heat, which is evolved during the clinkering operation, makes up to some extent for the large amount of heat required to calcine the material and drive off the carbon dioxide from the calcium and magnesium carbonates which form such a large proportion of the raw material. The data bearing on these heats of combination are open to some question, especially in view of the doubt as to the exact chemical compounds present in the clinker material. I may add that some of the other data contained in this paper do not seem to conform to regular cement practice. I am not, however, sufficiently informed as to the conditions under which these results were secured to make a detailed discussion of them.

H. E. Brown. I heartily agree with Professor Landis in reference to the heat generated by the action of the silicates of lime and alumina in rotary kilns. Le Chetelier[1] has done a great deal of work along these lines, and it is easy to determine from his work that in 1 lb. of cement clinker there is only about 170 B.t.u. generated.

[1]Revue de Metallurgy, October 1905.

In Par. 9 of Mr. Soper's paper, he states that the temperatures of the material were calculated by means of these data. It would be interesting to know how Mr. Soper can calculate the temperature of material from the data given, since there exists no accepted formulae or relation between heats of the gases and heats of the materials.

In the analysis shown in Fig. 5, the curve for CaO at Station 3 shows 68 per cent and then drops at the mouth of the kiln to 66.5 per cent. Such a variation runs counter to common practice, and throws a doubt upon the accuracy of the investigation.

In Fig. 2, under the diagram, he states: "Curve—2—Maximum Temperatures of Materials Calculated from Gas Temperatures. Temperature at Stations *B*, 1, 12 Actually Observed." He claims to have calculated the curve from the feed end of the kiln up to Station 1, but it is quite impossible to draw such a curve from any data of which I have knowledge.

Again, in Fig. 3, Mr. Soper has shown a cement containing 15 per cent of R_2O_3; and in Fig. 5 a cement with 66.5 per cent of CaO. These are such unusual portland cements that one is forced to question the accuracy of the analytical work. It would also add to the value of the paper if Mr. Soper would give in detail his method or formula for deriving the curves shown in Figs. 6 and 7.

W. B. Ruggles. In Fig. 7 Mr. Soper has shown the stress diagrams for the kiln in which there are three tires. The weight in the lower diagram is on the kiln's outer tires, the center tire not touching at the rollers. It is possible, on account of the warping effect of the heat in the kiln at certain intensities, that the whole weight of the kiln wlll rest on the center tire, in which case the stresses will be nearly double what the middle stress is on this diagram.

The Author. Referring to Par. 3 of my paper, perhaps I did not make myself quite clear regarding the use of pulverized coal. Fuel in this form had been used for other purposes than burning cement several years prior to 1895. It had also been used for burning cement previous to this date in Europe. What I meant to imply was that the Atlas was the first company in the United States successfully to adopt and maintain its use in the burning of portland cement clinker.

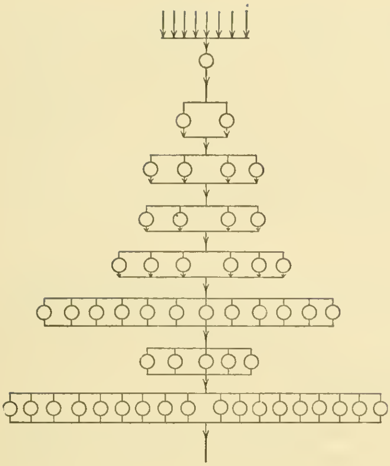
It might be interesting to compare or rather to contrast two mills, of say 2000 bbl. daily production, one built ten years ago (Fig. 10), and the other built last year (Fig. 11). Assuming both mills to be operat-

ing on the same materials and under similar conditions, the flow-sheet of the mills would be about as shown in Fig. 10 and 11, omitting the smaller details such as conveyors, elevators (represented by arrows), proportioning apparatus, bins, separators, feeders, etc. I have shown both systems of grinding, the two stage, or ball and tube, and the single stage, or Griffin or Fuller installations. I have omitted the fuel mill and the shale or clay departments, also the power plant. The growth here has been as marked, but the above examples will serve to illustrate in a general way the enormous advance that has been made in practically every step in the manufacture of portland cement. The main idea throughout this growth and development has been *simplicity, economy of operation* as to labor, supplies, etc., and a corresponding reduction in the cost of production.

Until the year 1907 the largest gyratory crusher built weighed 200,000 lb. It was called a No. 10, and was capable of receiving a 24-in. cube of rock. The Hunt Engineering Company of Kansas, with whom the writer was associated at that time, installed in a mill in the South a No. 18 gyratory, weighing 426,000 lb. and capable of receiving a 36-in. cube of rock. This single step, by reason of a reduction in labor through the use of a large steam shovel for loading the rock direct from the blast and a very appreciable decrease thereby in explosives, reduced the cost of production about $0.07 per bbl.

In crediting Mr. Edison with the biggest single advance in the industry, I referred more particularly to the burning department, since the saving of 40 lb. to 50 lb. of coal by his kiln over the 100-ft. kiln which was then in use in the American mills, effected an approximate saving of $0.04 to $0.05 per bbl. His "step" was no greater proportionately than that made by the fellow who increased his kiln from 20 ft. to 40 ft. and later from 40 ft. to 60 ft., but it came at a time when the business was assuming an important position in the commercial growth of the country, and Mr. Edison's already well-earned reputation for doing big things was as responsible for the coupling of his name with this improvement as the importance of the improvement itself.

The design and construction of the particular kiln employed by Mr. Edison would be adopted by few engineers or manufacturers because of the difficulty of keeping in alignment the carrying rolls and because of the extreme weight and cost, the shell being made up of cast-iron flanged sections 5 ft. in length, and each flange joint being machined and utilized as a tire. Mr. Ruggles' statement that the whole weight might



Laborers in quarries

No. 8 Gyratory Crusher, Weight 100,000 lb.

Two No. 4 Gyratory Crushers

Four 4 ft. by 30 ft. Rotary Dryers

Four No. 6 Ball Mills

Twenty 4 ft. by 16 ft. Tube Mills

Eleven 6 ft. by 60 ft. Rotary Kilns.

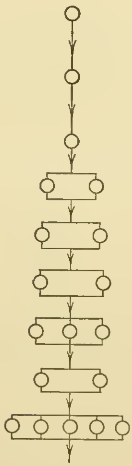
Five 4 ft. by 35 ft. Rotary Coolers

Eighteen 30-in. Griffin Mills (33-in. Fuller Mills not in use at this time)

Fig. 10 Flow-Sheet of Plant Built in 1900

Production of Country 8,482,000 bbl.

Cost of production per barrel, assuming coal at $2 per ton, was $1.00.



100-ton Steam Shovel (displaces 100 men)

One No. 22 Gyratory Crusher, Weight 600,000 lb.

One No. 6 Gyratory Crusher

Two 6 ft. by 60 ft. Rotary Dryers

Two 7 ft. by 7 ft. Ball Mills

Two 8 ft. by 26 ft. Tube Mills

Three 8 ft. 6 in. by 125 ft. Rotary Kilns

Two 6 ft. by 60 ft. Rotary Coolers

Five 54 in. Griffin Mills or Fuller Mills

Fig. 11 Flow-Sheet of Plant Built in 1910

Production of Country 74,000,000 bbl.

Cost of production per barrel, assuming coal at $2 per ton, was $0.60.

be carried on the center tire (Fig. 7) is difficult to imagine, as the kiln would not balance at this point, and either of the outer tires would touch, resulting in an extreme stress at the center tire, due to the increased overhang. Any two adjacent tires and the two outer tires can touch, but the case would be extremely rare when the whole weight is carried on the center tire. In this event there would unquestionably be an immediate failure through tearing of the sheets or shearing of the rivets or buckling.

I believe Mr. Meade is correct in stating that in no plant should a kiln having a capacity greater than 25 per cent of the total capacity of the plant be installed, assuming of course, the kilns to be of the same size, though the statement might be qualified to admit a kiln of 30 to 33 per cent of the capacity of the mill.

In Mr. Meade's equation of time plus temperature plus fineness equals clinker, (a constant), it would appear there were more variable elements than he gives. If the quantity of air blown into the kiln is varied, the fuel consumption and the output are affected. The amount of material or load in the kiln has a direct bearing on the fuel consumption per barrel, and the size of the load is affected by the incline or pitch of the kiln. This question of kiln capacities and fuel consumption brings us back to the admitted fact that *less fuel per barrel* is required in burning the so-called Lehigh or cement rock, which requires but 5 to 15 per cent additional material for correction and is *already intimately mixed by nature*, than in the case of two *independent materials* as lime rock and shale. The finer grinding of the raw materials admits of more intimate mixing and a cement rock ground to a fineness of 94 per cent through 100 mesh should not require more fuel in the kilns than two independent materials ground 98 per cent through 100 mesh, though the power consumed is greater in the second instance.

While fine grinding assists clinkering and reduces fuel consumption, I question whether the clinkering temperature is not correspondingly decreased. A finely ground material must pass through the kiln faster than a more coarsely ground product, assuming the coal burned per minute to be constant, but, taking the case of a raw-material dryer, which requires a certain number of pounds of coal per ton to dry rock crushed to $1\frac{1}{2}$ in. and under, and considerably less coal per ton to dry rock crushed to $\frac{3}{8}$ in. and under. It does not necessarily follow that the moisture in the rock is evaporated at a temperature less than 212 deg. fahr.

The variation of the silica and iron contents may vary the fuel con-

sumption and production, and the *personal equation* is an exceedingly important factor to be considered. I assume, however, that Mr. Meade intended these to be constant during the application of his formula.

As Mr. Meade so clearly states, all conditions remaining the same, *increasing the length decreases the fuel consumption*, though there are limiting lengths for each different diameter beyond which the fuel consumption increases. *Increasing the net diameter increases the production*, though there is a slight increase in production when the length is increased and a decrease in fuel consumption as the diameter is increased. The speeds of the larger kilns, so far as we have observed, are much slower than the small ones. A 6 ft. by 60 ft. kiln generally makes one revolution in 60 to 90 seconds while an 8 ft. by 125 ft. kiln requires from 2 to 4 minutes.

The heat balances at present must be based to so great an extent upon assumed conditions and experimental data, that their value is approximate and useful only for comparison purposes, though it is quite possible to determine fairly accurately several of the percentages of heat distribution. One of the important losses is by radiation. Mr. Edison overcomes this quite successfully by introducing a layer of ½-in. asbestos between the brick lining and the shell. The expense of this method however, is quite prohibitive.

Professor Landis' criticism of the temperature of the stack gases is correct as regards the dry process, but the conditions in the example were taken from ordinary practice. The stack temperature should be nearer 1000 deg. fahr., although we have noted instances where the temperature is less than this.

Different authorities gave varying figures for the heats of combination and decomposition. The amounts must necessarily be approximate and determined by experiment. The temperature at which CO_2 is driven off, I understand, is questioned. I believe that when this action is taking place the materials are not of the same temperature as the passing gases which, as observed in one instance, was approxinately 1600 deg. fahr.

Mr. Jeffries has brought up a subject which should receive very serious consideration from the manufacturer and the engineer. The gas producer has only lately been developed in sufficiently large units as to admit of its application to a modern cement kiln. There is one disturbing feature, however, that will have to be considered and experimented upon. In burning cement clinker with natural gas, approximately 2000 cu. ft. per bbl. are required. This gas con-

tains about 1000 B.t.u. per cu. ft. Ordinary producer gas contains less than 200 B.t.u. per cu. ft. When natural gas was first tried in Kansas, no air was used or mixed with the gas and the result was discouraging. A mixer or burner was finally evolved and different percentages of air necessary for the combustion of the gas were mixed and blown in with the gas. This amount of air has been steadily increased, the productions correspondingly increased and the fuel consumption decreased. If producer gas acts similarly to natural gas, there is some work to do to perfect the system, but it can be done and should eventually solve the fuel question by reducing the consumption approximately to that of the old stationary or vertical kilns.

Referring to Professor Carpenter's question regarding the output and fuel consumption of the 6 ft. by 60 ft. kiln in Par. 11, the figures are accurate, but this kiln was operating on wet materials and hence the low production and high fuel consumption.

I believe I have covered Professor Carpenter's opening remarks in the first part of my closure. However, his statement that Mr. Edison has developed a new principle of operation in connection with the long kiln is not quite clear to me; the same changes occur in the small kiln as in the large one and disregarding the drying feature, the changes take place relatively proportional to the length of the kiln.

I am very glad indeed to correct the obvious errors in the heat balance, though the final results are not greatly altered.

Replying to Mr. Brown, the temperatures of the gases were *actually observed.* The temperatures of the materials were calculated, considering those observed at Stations 1, 2 and 11 as follows: The temperature of the raw feed entering the kiln was 95 deg.; the stack gases (wet process), 456 deg.; approximately 33 ft. down the kiln from the feed end all the moisture had disappeared. It is assumed that the material was heated to 212 deg., remained fairly constant while the water was evaporated and gradually rose in temperature to 1000 deg., remaining at that temperature while the gases were liberated. The material was then gradually heated to clinkering temperature and remained constant until this action was completed and then cooled to the temperature of the discharged clinker which was observed. In making tests of this kind there is always the possibility of an error in the analytical work or in the calculations, but I doubt if there are any materials which when spread out over a surface 160 ft. long will conform to within 1 or 2 per cent of an assumed theoretically perfect case. There are very few cements on the market which conform closely to an *ideal* cement so far as chemical analyses are concerned.

I know of one which has contained as high as 10 to 12 per cent magnesia, but it apparently passed all the physical tests required of it. The formulae for the moment diagrams, etc., are simple mathematical equations found in most higher text books. The method of treating the weakening effect of the heat is based upon experiments and the use of a large factor of safety.

In the original calculations and the revision, the sensible heat in the raw mix and the coal was disregarded. Assuming the temperature of the stack gases to be 1000 deg. fahr., item *f* Par. 12 becomes

$$208.8\ (1000-70) \times 0.24 = 46{,}604 \text{ B.t.u.}$$

and using 18 lb. of gas for 1 lb. of coal as the products of combustion, and assuming an air supply twice that theoretically required, *g* Par. 12 becomes

$$90 \times 18 = 1620 \text{ lb. gases (waste) per bbl.}$$

$$1620\ (1000-70) \times 0.23 = 338{,}418 \text{ B.t.u.}$$

a, under Heat Delivered to Kiln, Par. 12, becomes

$$4(1000-70) \times 0.24 = 923 \text{ B.t.u.}$$

$$12421-923 = 11{,}498 \text{ B.t.u. available}$$

then

$$90 \times 11{,}498 = 1{,}034{,}820 \text{ B.t.u. total available heat of combustion}$$

The summary in Par. 12 can then be written:

Heat distribution in kiln

	B.t.u. per bbl.	Per Cent
a Dissociation of carbonates..........	357,000	27.6
b Heating 600 lb. dry raw mix from 60 deg. to 1000 deg. fahr..........	112,800	8.6
c Heating 380 lb. raw mix from 1000 deg. to 2500 deg. fahr............	136,800	10.5
e Radiation from shell and hood......	224,270	17.7
g Carried off by waste gases..........	338,418	26.2
Total............................	1,169,288	
Received by kiln....................	1,292,208	
Unaccounted difference (probably radiation)......................	122,920	9.5
Total............................		100.1

Heat received by kiln

	B.t.u. per bbl.	Per Cent
a Combustion of coal.	1,034,820	80
c Liberated by chemical reactions. . . .	247,662	19.1
d Delivered through air pipe.	9,750	0.9
Total available heat.	1,292,208	100

b becomes 0 since gases escape to stack at about the same temperature at which they are liberated.

The losses are

d Heat discharged with clinker.	118,500
e Radiation.	224,270
f Carried off by gases.	46,604
g Carried off by waste gases (products of combustion and excess air). . . . under heat distribution in kiln	338,418

A GRAPHICAL METHOD OF CALCULATING STRESSES IN A CONNECTING ROD

By W. H. Herschel, Published in The Journal for October 1910

ABSTRACT OF PAPER

To avoid the assumptions generally made in calculating stresses in a connecting rod by analytical formulae, a graphical method is proposed for finding the stress at any point of a rod of any shape. Determination of the inertia forces of material points is simplified by means of a diagram calculated from exact formulae. The bending moment due to inertia forces is calculated by the usual string polygon method, and there is also a moment equal to the axial method and a moment equal to the axial thrust multiplied by the sum of the deflection and an assumed eccentricity of loading. Deflections are found by Mohr's method and the eccentricity is assumed in accordance with the conclusions of Moncrieff.

The numerical examples show that in a simple shaft of uniform stress the maximum bending moment and maximum diameter will be less than 0.6 the length of the rod from the crosshead end, and the maximum bending moment at any one point will occur at about 38 per cent stroke. The stresses are much greater than given by the usual formulae, mainly on account of considering the bending moment due to axial thrust.

DISCUSSION

L. L. Willard. Mr. Herschel's paper is of interest as a graphical method of finding stresses in a connecting rod, and as far as reference to many formulae and methods goes. Something more valuable to engine designers, however, is a method of calculation which can be applied with little labor. With keen competition, such as has been experienced in the past few years, the engineering departments of manufacturing concerns are very seldom given time to investigate many interesting subjects which are not considered necessary.

Any successful builder of steam or gas engines must standardize as far as possible the parts which go to make up the engine, in order to reduce the cost of manufacturing. In steam engines, various steam

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

pressures are encountered, as in gas engines, due to the various compositions of gases. The maximum conditions from which the rods are designed are, therefore, taken. Many builders use the same rod for more than one size of cylinder, as long as the total pressure and revolutions per minute do not exceed the value for which the rod is designed.

It is true that the method devised by the writer and referred to in Mr. Herschel's paper (Pars. 8 and 25) is based on certain assumptions, but the value of e in Mr. Herschel's formula, which allows for the lack of homogeneity of material and eccentricity of loading is also apparently assumed. This value for homogeneity can probably be obtained for a line of connecting rods only by experiment or be based on known behavior of rods of similar design used in the past and then set at a maximum value.

It thus appears that while the usual assumptions are eliminated, as stated in the paper, others are necessary, so that judgment is still required in the selection of certain values about which no more is known than what is covered by the usual factor of safety allowed, taking care of inaccuracies in making diagrams, calculations and minor assumptions. The graphical method proposed is also much more complicated, the chances of error being increased thereby, and requiring a great deal more labor than usual. The results given seem to be no better for practical use than those obtained by shorter methods.

Gaetano Lanza. I have not yet published anything in regard to computing the stresses in rods. An article was published by George Goodell several years ago which was based on some work I had been doing, as he says in the paper. Since then I have figured, or had figured by students under my direction, the stresses in a number of rods. The discussion by Mr. Goodell can be very much simplified, so that the analytical determination of the stresses is neither very long nor very complicated.

The Author. In regard to Mr. Willard's objections that the method is complicated and that I have made an assumption in regard to the eccentricity of the loading, I think the fact that the method is complicated has no bearing on the question of whether the center of a rod or a point 0.6 of its length from one end is the proper place for the largest section. If there are analytical methods for designing a rod which are simpler and answer this question with equal cer-

tainty, I should like to learn of them. The assumption made by everyone that the eccentricity of loading, $e = o$, is no less an assumption than taking $\frac{ce}{r^2} = 0.6$. I am willing to admit, however, that this may give values too large for e, because the workmanship in connection rods would be on the average, much better than in the case of the columns considered by Moncrieff.

It has been stated that the maximum bending moment was approximately at 0.6 of the length of the rod from the end. This value of 0.6 (usually quoted from Grashof, but also derived by Bach) is obtained by assuming a rod of constant section; but even then it is not correct for a horizontal engine, since, as pointed out by Marks, the static weight of the rod brings the point of maximum bending moment nearer the center. As shown by the graphical method, neither the maximum bending moment nor the maximum stress is exactly at 0.577 of the length of the rod from the end. The exact locations of moment and of stress would undoubtedly depend on the amount of taper to the rod, and the amount of taper is usually a matter of judgment rather than of calculation. Some method seems to be required, therefore, which will indicate the correct amount of taper to use instead of being obliged to rely wholly on judgment in the matter.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE (V)

ARTICLES IN PERIODICALS

BRENNSTOFFE IM GASGENERATOR, DIE VERGASUNG MINDERWERTIGER, Gwosdz. *Braunkohle, January 27, February 3, 1911.* 11 pp., 10 figs., 4 tables. *abfB.*

Comparative data on heating value of minor-grade fuels. Describes various systems where low-grade fuels as coal dust, coke dust, cinder, gathered from locomotive boiler flues, wet peat and wood shavings are utilized economically in the gas producer.

CARBURETTERS AND VAPORIZERS, T. A. Borthwick. *Cassier's Magazine, February 1911.* 6 pp., 7 figs. *abf.*

Discusses various forms used in the development of the combustible motor for converting liquid combustible into a gaseous state.

COSTS IN INDUSTRIAL POWER PLANTS, COMMENTS ON FIXED, John C. Parker, *Proceedings A.I.E.E., March 1911.* 16 pp., 6 tables, 1 curve.

Last part of article refers especially to gas-engine and producer plants.

DREHKOLBEN-VERBRENNUNGSMASCHINEN, ÜBER, W. Gentsch. *Die Turbine. January 20, February 5, 1911.* 17 pp., 58 figs. *abd.*

Deals with rotating-piston internal-combustion machines.

DREHROST-GASERZEUGER BAUART HILGER, DER, Georg Kassel. *Stahl and Eisen, January 19, 1911.* 4 pp., 6 figs., 2 tables. *ab.*

Deals with revolving-grate gas generator; gives diversity of opinion as to value of water-jacket cheaper to install and operate without the jacket.

EFFICIENCY OF A TWO-CYCLE ENGINE, THE THERMAL. *The Gas Engine, March 1911.* 2 pp., 3 tables.

Extracts of paper by W. Watson and R. W. Fenning, before the English Institution of Automobile Engineers. Tables show results of test at several speeds and corresponding piston speeds and mean effective pressure in lb. per sq. in.

Opinions expressed are those of the reviewer, not of the Society. Articles are classified as: *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal forMay 1910.

Engine, A New Ajax Gas. *Power, January 24, 1911.* 2⅓ pp., 6 figs.

Engines at the Brussels Exhibition, International Combustion, Percy R. Allen. *Cassier's Magazine, February 1911.* 21 pp., 20 figs. *bdfa.* Also *March 1911.* 31 pp., 31 figs., 1 table. *bf.*

First describes gas engines, producers and the Humphrey pump; detailed description of Cocherill twin-tandem engine, Ballinckx suction gas producer, Crossley engine and producer, Campbell engine and producer, Ruston and Proctor engine, valve gear and producer. Second describes liquid fuel engines; detailed description of Diesel engines, Brons vertical engine, Daimler reversible marine engine, Blackstone engine, Crossley reversing gear, Campbell crude-oil engine and vaporizer, Ruston and Proctor engine, oil, feed and valve gear, and others, with indicator cards, etc.

Engines, Large Two-Cycle Gas. *The Engineer (London), March 3, 1911.* 1. p., 3 figs.

Extract of paper by Alan E. L. Chorlton, before the Manchester Association of Engineers. Treats of large two-cycle internal-combustion engines, their design, redesign and erection; also a description of exhaust boilers in connection with gas engines and their location relative to the engines.

Explosionsmaschinen mit Wassereinspritzung, K. Schreber. *Die Gasmotorentechnik, January 1911.* 2½ pp., 1 fig.

Four a Coke, Le Chauffage des Four Martin par du Gaz de, Em. Trasenster. *Revue Universelle des Mines, de la Métallurgie, November 1910.* 4 pp., 2 tables.

Heating of a Martin furnace by the gases from a coke oven.

Fuels, The Calorific Value of Solid and Liquid, W. Inchly. *The Engineer (London), February 17, 1911.* 2 pp., 2 tables, *ce.*

Criticism of existing formulae and analyses of different fuels.

Gasoline and the Impurities that are being Encountered, Commercial. F. H. Floyd. *The Gas Engine, February 1911.* 6 pp., 2 tables.

Gasreinigungsverfahren, Über ein neues, Friedrich Müller. *Stahl und Eisen, February 9, 1911.* 3 pp., 1 fig., 1 table, 4 curves. *ab.*

Comparative costs of installation and of operation of wet and dry methods of scrubbing.

Gaswerke in London, Edinburgh, Glasgow. *Journal für Gasbeleuchtung und Wasserversorgung, February 11, 1911.* 5 pp., 10 figs., *abf.*

Report and description of municipal gas plant.

Gazogener Récents Quelques, Gustave Richard. *Revue de Méchanique, December 31, 1910.* 40 pp., 60 figs., 3 tables. *A.*

Exhaustive article on modern gas producer.

GENERATOREN FÜR MINDERWERTIGE BRENNSTOFFE, DIE, Gwosdz. *Die Gasmotorentechnik, February 1911.* 3 pp., 2 figs. *b.*

JUNTAS Y EMPAQUETADURES EN LOS MOTORES DE GAS. *El Comercio, January 15, 1911.* $\frac{1}{4}$p.

Manner of placing and maintaining joint-packing for gas engines. Gives preference to ground joints.

MOTEUR À EXPLOSIONS SYSTÈME ROOTS, G. Noël. *Fer et Acier, January 1911.* 3 pp., 4 figs. *bf.*

Describes remarkable arrangement of cylinders, pistons, etc., of a new gasolene motor.

PATENTE AUS DEM VERBRENNUNGS-MASCHINENBAU, NEUERE, R. Barkow. *Dinglers Polytechnishes Journal, February 18, 1911.* $3\frac{1}{2}$ pp., 16 figs. *bf.*

New valve arrangement for large gas engines.

POWER PLANT AT HONG-KONG, A LARGE GAS. *The Engineer (London), February 24, 1911.* $2\frac{1}{2}$ pp., 6 figs. *bf.*

Describes installation of Cocherill-Westgarth engines and Mond gas producers at the Taikoo dockyard.

POWER-PLANT DEVELOPMENT IN EUROPE, FEATURES OF PRODUCER-GAS, R. H. Fernald. *The Gas Engine, March 1911.* 5 pp.

Extract from Bulletin 4, U. S. Bureau of Mines. Details of several plants giving kind and number of producers, engines and scrubbers used; also kind of fuel and cost.

POWER, SOME PERTINENT FEATURES RELATING TO GAS, E. D. Dreyfus. *The Electric Journal, January 1911.* 11 pp., 3 figs., 3 tables, 4 curves.

Extract of paper before the Pittsburg Railway Club. Comparison of different power gases, economic value as compared with steam power. Notes on different types of engines and producers, maintenance and installation costs.

POWER, THE COST OF INDUSTRIAL, Aldis E. Hibner. *Proceedings A.I.E.E., March 1911.* 11 pp., 3 tables, 4 curves. *a.*

PRODUCER, THE HILGER REVOLVING GRATE GAS. *The Iron Age, March 2, 1911.* 1 p., 3 figs., 1 table. *b.*

Grate with forward and backward motion; patented ash removal device. Analyses of gas obtained with this producer.

VÁLVULAS DE LOS MOTORES DE GAS. *El Comercio, January 15, 1911.* $\frac{1}{8}$ p. *b.*

Alleged faulty designs and suggestions for better construction.

VALVE SYSTEMS, NOVELTIES IN, E. P. Batzell. *The Gas Engine, February 1911.* 8 pp., 8 figs., 1 curve.

Paper before the Society of Automobile Engineers, New York. Discussion on the various types of valves and their application to small engines.

VERBRENNUNGSKRAFTMASCHINEN, DIE REVERSIERUNG VON, Ernst Valentin. *Die Gasmotorentechnik, February 1911.* 3 pp. 7 figs. *ab.*

GENERAL NOTES

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

At a meeting of the American Institute of Electrical Engineers to be held in Toronto, Ont., April 7, a paper will be presented by W. S. Murray, electrical engineer of the N.Y.N.H. & H.R.R. Co., entitled Analysis of Electrification and Its Practical Application to Trunk Lines for Freight and Passenger Operation. At the April 14 meeting of the institute in New York, two papers will be presented on the general subject of The Effect of Temperature upon the Hysteresis Loss in Sheet Steel, by Malcolm MacLaren, professor of electrical engineering at Princeton University, and by L. T. Robinson of the General Electric Company. A Pacific Coast meeting will be held at Los Angeles, Cal., April 25–28, at which the following papers will be presented: The Refining of Iron and Steel by Induction Type Furnaces, C. T. Elwell; Auto-Manual Telephone System, E. E. Clement; New Automatic Telephone Equipment, C. S. Winston; Continuity of Service in Transmission Systems, M. T. Crawford; Transmission Systems from the Operating Standpoint, R. J. C. Wood; A Power Diagram Indicator for High-Tension Circuits, H. J. Ryan, Mem.Am.Soc.M.E.; Electricity in the Lumber Industry, E. J. Barry; Transmission Applied to Irrigation, O. H. Ensign and J. M. Gaylord; Some Recent Developments in Railway Telephony, G. Brown; Cisoidal Oscillations, G. A. Campbell.

AMERICAN SOCIETY OF CIVIL ENGINEERS

At the bi-monthly meeting of the American Society of Civil Engineers on March 1, Albert R. Raynor read a paper on The Pittsburg and Lake Erie Cantilever Bridge over the Ohio River at Beaver, Pa. On March 15, a paper on Dams on Sand Foundations; Some Principles Involved in Their Design and the Law Governing the Depth of Penetration Required for Sheet Piling was presented.

The society's excursion to Panama began March 2, with the sailing of the United Fruit Company's steamer, Zacapa, from New York. The party was to be joined in Panama by a second one sailing from New Orleans, La., March 4.

It has been announced that the next annual convention of the society will be held at Chattanooga, Tenn., June 13–16.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION

The annual convention of the American Railway Engineering and Maintenance of Way Association was held in Chicago, Ill., March 21 to 23, with headquarters at the Hotel Congress. Reports on the following were presented: Rules and Organization, Signals and Interlocking, Electricity, Brine Drippings from Refrigerator Cars, Yards and Terminals, Wooden Bridges and Trestles,

Iron and Steel Structures, Economics of Railway Location, Ballast, Ties, Track Rail Masonry, Water Service, Signs, Fences and Crossings, Records and Accounts, Wood Preservation, Grading Rules for Maintenance of Way Lumber, Buildings, Roadway, Uniform General Contract Forms, Conservation of Natural Resources. An illustrated lecture on Steel Rails was given by M. H. Wickhorst. The Railway Signal Association and the Railway Appliance Association held meetings and exhibitions in Chicago at the same time and members of the America Railway Engineering and Maintenance of Way Association attended many of their sessions.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION

At the seventh annual convention of the Northwestern Cement Products Association in Minneapolis, Minn., February 28–March 1, papers were presented as follows: Stucco Finishes, E. McCullough; Cement Drain Tile Plants, C. M. Powell; Economies in Concrete Products, M. T. Roche: Manufacture of Cement Drain Tile, C. E. Sims; Cast Stone Work, C. A. P. Turner; Reinforced Concrete Construction in Minneapolis, J. Houghton; Concrete Highwater Bridges, A. E. Lindau.

CHEMISTS' CLUB

The Chemists' Building at 50 East 41st Street, New York, was inaugurated March 17. It is intended not only to supply the social needs of the Chemists' Club, but to serve also as a meeting place for the New York section of the American Chemical Society. The Institute of Chemical Industry and the American Electrochemical Society will also hold meetings in the new building. The ground floor is devoted to a public entrance hall and foyer, back of which is a large lecture room. On the next floor are a social room and restaurant of the Chemists' Club and on the floor above this are the library, the museum and the trustees' room. The fourth and fifth floors are occupied by members' bedrooms. The five floors constituting the upper half of the building are devoted to laboratories completely equipped for investigators in pure and applied science.

The program of opening exercises extended over three days and consisted in part of addresses by many prominent in the world of chemistry and lectures on Rare Gases of the Atmosphere, R. B. Moore; Characteristics of Living Matter from the Physico-Chemical Point of View, J. Loeb; Mental Catalysis, W. R. Whitney; Chemistry of Phosphorescence, W. D. Bancroft; The Contribution of Chemistry to Sanitation, W. P. Mason; The History of Chemical Industry in New York City, C. F. Chandler. A banquet in the new club rooms and a classical concert concluded the exercises.

CANADIAN CEMENT AND CONCRETE ASSOCIATION

The third annual convention of the Canadian Cement and Concrete Association was held in Toronto, Canada, March 6 to 9. The Toronto Cement Show, under the auspices of the Canadian Cement and Concrete Association, was in progress at the same time at the St. Lawrence Arena, and added much to the interest of the occasion. The convention was opened with an address by the president, Peter Gillespie, on Theory of Construction. Other papers read were

Concrete Blocks, R. F. Havlick; Grading Stone Aggregate, H. P. Bowes; Manufacture of Portland Cement, W. M. Kinney; The White and the Gray, J. M. Carrere; Prevention of Corrosion in Metal Lath, C. W. Noble; The Necessity of Inspection in Concrete Work, E. A. James; Concrete in Factory Construction, B. H. Prack; Cement Concrete in Highway Construction, W. A. McLean; Cement Surfaces and Finishes, Robt. Cathcart; A Few Points on Reinforced Concrete Design, C. S. L. Hertzberg. At the joint session with the Engineers' Club of Toronto there were two papers presented, one on Building By-Laws and Reinforced Concrete, Richard L. Humphrey; and another on Adaptation of Concrete for Long Span Bridges, Frank Barber.

CANADIAN MINING INSTITUTE

At the annual meeting of the Canadian Mining Institute held at the Chateau Frontenac, Quebec, Que., March 1–3, papers were presented on The Engineering Problems of Geological Nature Afforded by the New Catskill Aqueduct of New York City, J. F. Kemp; Asbestos Deposits of the New England States, C. H. Richardson; A New Type of Electrically Driven Long-Wall Machine, G. D. Burchell; and many others. An excursion to Montmorency Falls was enjoyed by the members attending the meeting.

PERSONALS

Charles H. Baker has been appointed chief engineer, Zylonite Power Station of the Boston & Maine Railroad, Adams, Mass. He was recently assistant chief engineer, Cos Cob Power Station, Cos Cob, Conn.

Charles H. Bigelow, recently associated with Charles T. Main, Boston, Mass., has become connected with the Yale & Towne Manufacturing Co., Stamford, Conn., as assistant superintendent of Power and Plant.

George L. Bourne, formerly vice-president of the Railway Materials Co., Chicago, Ill., has become connected with the Locomotive Superheater Co. of the same city, in a similar capacity.

Sterling H. Bunnell, recently associated with the Griscom-Spencer Co., New York, has been appointed consulting engineer of the Clinton H. Scovell Co., New York.

E. L. Hill, formerly assistant engineer in the district manager's office of the American Steel & Wire Co., Worcester, Mass., has been recently appointed assistant superintendent of the company's electrical cable work in that city.

M. W. Hogel, until recently engineer of tests at the Indiana Steel Co., Gary, Ind., has accepted the position of assistant works manager of The T. H. Symington Co., Rochester, N. Y.

G. L. Kothny has left the employ of the British Westinghouse Electric & Manufacturing Co. to accept the position of manager of the Great Britain Société Anonyme Westinghouse, London, England.

Grant W. Lillie has become assistant superintendent of the Oregon Short Line Railroad Co., Pocatello, Idaho. He was formerly superintendent of shops, St. Louis & San Francisco Railroad, Springfield, Mo.

W. G. Lunger has resigned his position as manager of the Chicago branch of the Union Twist Drill Co. to accept the position of manager of the furnace department of the American Shop Equipment Co., Chicago, Ill.

Henry B. Oatley formerly associated with the American Locomotive Co., Schenectady, N. Y., as assistant engineer of the general drawing room, has become affiliated with the Locomotive Superheater Co., New York.

William F. Parish, Jr., recently connected with the Deutsche Vacuum Oil Co., Hamburg, Germany, as chief engineer, has become associated with The Texas Co., New York.

Percy A. Robbins has become identified with the Hollinger Gold Mines, Porcupine, Ontario, Canada. He was formerly connected with the McKinley-Darragh Mine, Cobalt, Canada, in the capacity of general manager.

Max Rotter has become affiliated with Busch-Sulzer Bros., Diesel Engine Co., St. Louis, Mo., in the capacity of chief engineer. Mr. Rotter was formerly connected with the Allis-Chalmers Co., Milwaukee, Wis., in the same capacity.

Col. Edwin A. Stevens has been appointed Commissioner of Public Roads of New Jersey.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society, included in the Engineering Library. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am.Soc.M.E.

American Producer Gas Practice and Industrial Gas Engineering. By Nisbet Latta. *New York, D. Van Nostrand Co., 1910.*

The American Society of Mechanical Engineers. Year Book. 1911. *New York, 1911.*

Boletin de Ingenieros. Vol. 1. No. 6. February, 1911. *Mexico, 1911.*

Boston Transit Commission. 16th Annual Report. 1910. *Boston, 1910.* Gift of the commission.

Chemistry and Testing of Cement. By C. H. Desch. *London, E. Arnold, 1911.*

Commission des Méthodes d' Essai des Matériaux de Construction. 2d Session. Vols. 2–3. *Paris, 1900.*

Contracts in Engineering. By J. I. Tucker. *New York, McGraw-Hill Book Co., 1910.*

Cornish Magazine. *Truro.* Gift of R. I. Kirton.

De Laval Steam Turbines for both High and Low Pressure. (Reprinted from Iron Age.) *Trenton.* Gift of De Laval Steam Turbine Co.

Design of Electric Overhead Cranes, Crabs, Gearing and Brake Mechanism. By R. B. Brown. ed. 2. *New York, Industrial Press, 1910.*

Detroit Board of Water Commissioners. 58th Annual Report. 1910. *Detroit, 1910.* Gift of the board.

Eisenkonstruktionen der Ingenieur-Hochbauten. 4 Jahrgang. *Leipzig, 1909.*

Gas Petrol and Oil Engine. By Dugald Clerk. Vol. 1. *New York, J. Wiley & Sons, 1909.*

Heat Engines. By J. R. Allen and J. A. Bursley. *New York, McGraw-Hill Book Co., 1910.*

Illinois Mine Rescue Station Commission. Report to the Governor and General Assembly. From August 1, 1910 to December 31, 1910. *Springfield, 1911.* Gift of the commission.

Influence of Multi-Point Ignition on the Efficiency and Output of Internal-Combustion Engines. By Otto Heins. *New York, 1911.* Gift of Bosch Magneto Co.

Insurance Library Association of Boston. Bulletin. January 1911. Gift of the association.

International Congress of Applied Chemistry. 8th Preliminary Announcement. Opening meeting, September 4, 1912. Gift of the congress.

Machine Design. By A. W. Smith and G. H. Marx. ed. 3. *New York, J. Wiley & Sons, 1909.*

Machine Shop Drawing. By F. H. Colvin. *New York, McGraw-Hill Book Co., 1909.*

Mechanics' and Engineers' Pocket Book. By C. H. Haswell. ed. 74. *New York, Harper & Bros., 1909.*

Metallographie. By W. Guertler. Vol. 1. pt. 5.

Michigan Electric Association. Proceedings. 1910. *Port Huron, 1910.* Gift of the association.

Missouri Waterway Commission. 1st Biennial Report. 1911. *Jefferson City, 1911.* Gift of the commission.

Modern Methods of Water Purification. By John Don and John Chisholm. *London, E. Arnold, 1911.*

New York City Docks and Ferries Department. Reply to Criticisms of Reports of the Department of Docks and Ferries relating to Manhattan Terminals at the Port of New York. *New York, 1910.*

——Report accompanying Submission of Plans for an Elevated Freight Railroad Connecting Manhattan Terminals at the Port of New York. *January 26, 1911.*

——Report on Transportation Conditions at the Port of New York. *July 1910.*

——Supplementary Report on Manhattan Terminals at the Port of New York. *New York, 1910.*

New York State Commissioner of Excise. Report of Maynard N. Clement. 1910. *Albany, 1911.* Gift of the author.

Parallel Tables of Logarithms and Squares. By C. Smoley. ed. 6. *New York, Engineering News Pub. Co., 1911.*

Railroads and the People. By E. P. Ripley. (Reprinted from the Atlantic Monthly, January 1911.) *Boston, 1911.*

Visit to His Majesty's Mint, Calcutta, by Kind Invitation from Capt. G. H. Willis, January 21, 1911. By A. Dryden. (Reprinted from the Institution of Mechanical Engineers.) Gift of the author.

Water Power for the Farm and Country Home. By D. R. Cooper. *Albany.* Gift of State of New York Water Supply Commission.

Watuppa Water Board. 37th Annual Report to the City Council of the City of Fall River, Mass. 1911. *Fall River, 1911.* Gift of Fall River Water Works.

Welding, Theory, Practice, Apparatus and Tests. By R. N. Hart. *New York, McGraw-Hill Book Co., 1910.*

UNITED ENGINEERING SOCIETY

Coal Mining Institute of America. Proceedings. 1908, 1909. Gift of the Institute.

Congressional Directory. 61st Congress. 3d Session. 1911. *Washington, 1911.* Gift of Senator Elihu Root.

Pennsylvania Railroad Company. Specifications. Nos. 1–*C*; 2; 3–*A*; 4–*A*; 5–*A*; 6; 7–*C*; 8; 9–*F*; 10–*D*; 11–*C*; 12–*F*; 13; 14–*C*; 15; 16; 17; 18; 20–*A*; 21; 22–*A*; 23–*A*; 24–*A*; 25–*B*; 26; 27–*A*; 28–*A*; 29–*F*; 30–*A*; 31–*A*; 32–*C*; 33–*F*; 34–*A*; 35–*A*; 36–*A*; 38–*A*; 39–*C*; 40–*A*; 41–*A*; 42; 43–*A*; 44–*D*; 45–*A*; 46–*B*; 47; 48; 49–*A*; 50; 52–*A*; 53; 54–*C*; 55–*A*; 56; 57; 59–*B*; 60–*B*; 61; 62; 64; 65; 66; 72; 73; 74–*A*; 75–*A*; 78; 78–*B*; 80–*A*; 88–*A*; 101; 102; 104; 106–*C*; 107–*A*; 120; 121; 122. Gift of the company.

Recommendations and General Plans for a Comprehensive Passenger Subway System for the City of Chicago. By B. J. Arnold. *January 1911.* Gift of the author.

San Francisco Association of Members of the American Society of Civil Engineers. Constitution and List of Members, 1911.

Test of a Parsons Type Steam Turbine. By R. C. Carpenter. (Reprinted from Sibley Journal of Engineering, January 1911.) Gift of the author.

Traveling Engineers' Association. Proceedings of 4th, 6th, 8th–14th and 17th Annual Conventions. 1896, 1898, 1900–1906, 1909. Gift of the association.

Treatise on Masonry Construction. By I. O. Baker. ed. 10. *New York, J. Wiley & Sons, 1910.*

University of Cincinnati. Catalogue. 1910–1911. *Cincinnati, 1910.*

Valve Settings. By H. E. Collins. *New York, McGraw-Hill Book Co., 1908.*

EXCHANGES

American Society of Refrigerating Engineers. Transactions. Vols. 1–3. 1905–1907. *New York.*

Incorporated Institution of Automobile Engineers Proceedings. Vol. 4, 1909–1910. *Westminster, 1910.*

Junior Institution of Engineers. Journal and Record of Transactions. Vol. 20. 1909–1910. *London, 1910.*

Sächsischer Dampfkessel-Revisions-Verein Chemnitz. Ingenieur Bericht, 1910. *Chemnitz, 1910.*

TRADE CATALOGUES

Bristol Co., *Waterbury, Conn.* Bull. no. 127, Bristol's Class 3 recording thermometers, 39 pp.

John W. Ferguson Co., *Paterson, N. J.* Photographs of work executed by the company, 108 pp.

Lagonda Mfg. Co., *Springfield, O.* Weinland tube cleaners, 48 pp.

Lehigh Clutch Co., *Catasauqua, Pa.* Friction clutches, 3 pp.

F. E. Myers & Bros., *Ashland, O.* Pumps, agricultural implements and tools, 404 pp.

National Electric Lamp Assoc., *Cleveland, O.* Bull. no. 15, Electric Sign Lighting, 15 pp.; Bull. no. 8*B*, Mazda miniature and low-voltage lamps, 11 pp.; Bull. no. 5*C*, Tantalum multiple lamps, 11 pp.

National Water Softener Sales Co., *Indianapolis, Ind.* Water softeners, 15 pp.

L. H. Nielson, *Pittsburg, Pa.* Safety operator for elevators, 16 pp.

Ohio Brass Co., *Mansfield, O.*, Bull., Jan.–Feb. 1911, Electric railway and mine haulage material, 24 pp.

Platt Iron Works Co., *Dayton, O.* Smith-Vaile air compressors, steam and power actuated, 39 pp.; Smith-Vaile boiler feed pumps, 35 pp.; Victor-Francis turbines, 24 pp.

POTT, CASSELS & WILLIAMSON, *Motherwell, Scotland.* Water-driven centrifugals "Weston" type with patent interlocking gear, 23 pp.; Catalogue of centrifugal machinery, 170 pp.

PRECISION INSTRUMENT CO., *Detroit, Mich.* Precision Simmance-Abady CO_2 combustion recorder, 16 pp.

STANDARD SCALE & SUPPLY CO., *Pittsburg, Pa.* Catalogue of standard scales, 128 pp.

STEPHENS-ADAMSON MFG. CO., *Aurora, Ill.* The Labor Saver No. 33, devoted to labor saving devices, 24 pp.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

079 Wanted, by Ohio company building stationary engines, energetic and competent engineer to take charge of the shop as superintendent. Must be familiar with modern methods of turning out work and able to put them into practice. Good opportunity for the right man.

080 Chief draftsman for plant engaged in automobile work, desirable that applicant have had experience in this line of work, although not so essential as that he be energetic, thorough and reliable and have had experience in charge of drafting room. Willing to pay right man what he is worth. Location, New England states.

081 Machine designer with both technical and shop training, designing high-speed machines along new lines, requiring initiative, ingenuity, good judgment as to the use of materials and construction and thorough knowledge of shop and foundry work. To man of right experience, permanent position with every possibility of advancement if value is proved. Location, Michigan.

082 In engineering department of large steel company, assistant steam engineer. Technical graduate having at least four years' experience in similar lines. Location, Pennsylvania.

083 Superintendent of factory manufacturing brass goods, mainly sheet metal work. Will be required to reorganize and bring up to date entire factory system under principles of scientific management. Location, Connecticut.

MEN AVAILABLE

179 Technical graduate, age 33, 12 years' practical experience in mechanical department of railroads from machinist apprentice to superintendent of motive power. Executive ability and considerable experience in handling men. Desires responsible position with railroad or large manufacturing concern.

180 Mass. Inst. Tech. graduate, '97, fourteen years' experience in manufacturing, involving machine, foundry and boiler shop practice, desires change with view to bettering present conditions.

181 Graduate mechanical engineer; assistant professor of mechanical engineering and superintendent of shops in state university; desires position on faculty of technical college or university. Seven years' experience in teaching, and wide experience in all branches of shop practice.

182 Mechanical and structural engineer, wide experience in charge of design of furnace and rolling mills, general steel plant construction; desires position as chief draftsman or assistant engineer.

183 Member, 12 years' experience, machine, mill equipment, power plant design and field work. Good office experience. Chief draftsman, technical and practical training; desires change of position.

184 Position desired with construction firm or manufacturing company, machinery line preferred, as assistant to superintendent or manager. Thoroughly experienced in office detail, cost systems, etc., considerable experience in field construction work. Age 32, married.

185 Mechanical engineer, eight years' standing, one year additional in electrical engineering; now in charge of six large plants; desires position with power production or manufacturing concern vicinity of New York.

186 Mechanical engineer with several years' experience in engine works; past ten years head of strong engineering college in prominent university, desires a change. Responsible teaching position preferred.

187 Associate member, chief draftsman, designer or shop superintendent, expert in machine work, tool and manufacturing; good organizer and system man on shop costs and production; resourceful in design and processes for increasing production small and medium heavy interchangeable work. Location, New Jersey or New York.

188 Member, desires to connect with manufacturing, contracting or engineering firm, in any capacity requiring mature judgment and executive ability. Has had wide experience in mechanical work and some electrical, from drafting room to supervision. Sales engineer during past three years. Technical graduate, age 33. Position requiring progressive business ability as well as technical capacity desired. Location, Philadelphia.

189 Member, age 46; present occupying an executive position with large machinery manufacturers, desires engagement with either manufacturing or selling departments of live, growing concern. Engines, turbines, electrical machinery, power transmission or similar lines.

190 Mechanical engineer, 15 years' practical experience designing and building various lines of heavy machinery, competent to manage large engineering proposition. Now engineering executive for large corporation.

191 High class electrical engineer, age 30, desires to locate as office partner to consulting mechanical engineer with office in New York.

192 Member, 20 years' experience in engineering educational work, including shops, drafting, lectures, laboratory and administration, with special reference to mechanics, steam, hydraulic and industrial engineering, and power plants; open to engagement at close of present term of contract.

193 Junior, technical graduate in mechanical engineering, several years' practical experience in general drafting and engineering work; desires to make change. At present employed as mechanical draftsman. Desires to locate in or near New York.

194 Graduate M.E., age 25, employed as instructor in mechanical engineering in prominent eastern university; shop, drafting-room and office experience; prefers position as assistant superintendent, engineer or assistant professorship.

195 Graduate mechanical engineer, four years' standing, experienced in factory installation and mechanical superintendence; desires connection with large interests in capacity leading to position of mechanical superintendent of works or mill engineer.

196 Affiliate member, technical education, shop experience four and one-half years, drafting-room five years, gas and gasolene engines and gas producers. Design and construction of gas tractors, stationary engines and automobiles. Desires position as superintendent or assistant superintendent where knowledge of design and modern practice will be of value.

197 Mechanical engineer and designer of pumping machinery and water works installations; desires to make change. Nineteen years' experience designing and estimating on pumps, condensers and complete water works plants.

198 Junior, age 28, married, technical education; practical machinist, nine years as draftsman, designer, chief draftsman and general superintendent with present concern, building heavy machine tools and special machinery on interchangeable basis. Desires position as superintendent or manager. Salary, $2400.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ALEXANDER, Ludwell Brooke (Junior, 1905), Asst. Ch. of Dept., Bosch Magneto Co., 223 W. 46th St., and Cliffwood Court, 179th St., and Ft. Washington Ave., New York, N. Y.

AUE, Joseph E. (1899), Snow Steam Pump Wks., Buffalo, and *for mail*, 2968 Decatur Ave., New York, N. Y.

BAILEY, William J. (Junior, 1910), United Coal Co., Pa. Bldg., Philadelphia, Pa.

BAKER, Charles H. (Junior, 1903), Ch. Engr., Boston & Maine R. R., Zylonite Power Sta., Adams, Mass.

BIBBINS, James Rowland (1904; 1909), Engr. with Bion J. Arnold, 154 Nassau St., New York, N. Y., and Council Clerks Office, City Hall, Providence, R. I.

BIGELOW, Charles H. (1904), Asst. Supt., P. & P., Yale & Towne Mfg. Co., Stamford, Conn.

BOURNE, George L. (1903), V. P., Loco. Superheater Co., Peoples Gas Bldg., and 5133 Ellis Ave., Chicago, Ill.

BRADLEY, Carl D. (1907), Pres., Samuel L. Moore & Sons Corp., Elizabeth, N. J., and *for mail*, Machinery Club, 50 Church St., New York, N. Y.

BURCHARD, Anson W. (1888; 1891), 777 Madison Ave., New York, N. Y.

BUNNELL, Sterling Haight (1894; 1903), Cons. Engr., Clinton H. Scovell & Co., 90 West St., and 519 W. 121st St., New York, N. Y.

BURTON, Frank H. (1900), 6 Selkirk Rd., Brookline, Mass.

COOLEY, Hugh Nelson (Associate, 1910), Rep., Nordberg Mfg. Co. in Southwestern U. S. and Mexico, and *for mail*, No. 4, 1116 N. Oregon St., El Paso, Tex.

COWLES, William Barnum (1881), Industrial Expt. and Cons. Engr., 26 Alfred St., Detroit, Mich.

DURANT, Aldrich (Junior, 1906), MacArthur-Perks Co., Ltd., Havana, Cuba.

FLETEMEYER, Louis H. (Junior, 1906), Ch. Draftsman, Canada Fdy. Co., Ltd., and *for mail*, 41 Walter St., Toronto, Ont., Canada.

GAST, George Fred (Junior, 1910), Ch. Draftsman and Constr. Engr., with Walter Kidde, 140 Cedar St., New York, N. Y., and *for mail*, 2027 Oakland Ave., Minneapolis, Minn.

GREEN, Chas. Henry (Junior, 1905), 617 Peyton Bldg., Spokane, Wash.

HILL, Edgar Logan (Junior, 1908), Asst. Supt., Elec., Cable Wk., Am. Steel & Wire Co., and *for mail*, P. O. Box 553, Worcester, Mass.

HIRT, Louis Joseph (1894), Mech. Engr., Broad Exch. Bldg., 25 Broad St., New York, and *for mail*, 75 Farnham Ave., Yonkers, N. Y.

HOGLE, Milton W. (1901; Associate, 1906), Asst. Wks. Mgr., The T. H. Symington Co., and *for mail*, 128 Linden St., Rochester, N. Y.

HOY, Austin Y. (Junior, 1906,) Northwestern Mgr., Sullivan Mchy. Co., Hutton Bldg., and Pennington Hotel, Spokane, Wash.

KOTHNY, Gottdank Lebrecht (Junior, 1905), Mgr., Great Britain Societé Anonyme Westinghouse, 82 York Rd., Kings Cross, London, N., England.

LAPE, Willard E. (1890), care W. D. Garrett & Co., 136 Liberty St., New York, N. Y., and 109 Dodd Pl., East Orange, N. J.

LATTA, Nisbet (Junior, 1902), Wisconsin Eng. Co., Corliss, Wis.

LEE, R. E. (Junior, 1907), R. F. D. 2, Charlottesville, Va.

LEE, Wm. F. (1907), West New Brighton, S. I., N. Y.

LILLIE, Grant W. (Junior, 1901), Asst. Supt., Oregon Short Line R. R. Co., Pocatello, Idaho.

LUFKIN, Elgood Chauncey (1896), V. P., The Texas Co., 17 Battery Pl., New York, N. Y.

LUNGER, Waldo G. (Junior, 1901), Mgr., Furnace Dept., Am. Shop Equipment Co., McCormick Bldg., 193 Michigan Ave., Chicago, and 935 Hinman Ave., Evanston, Ill.

McMILLAN, Chas. M. (Junior, 1909), Gas Eng. Specialist, 1324 Arabella St., New Orleans, La.

MATTICE, Asa M. (1889), Manager, 1903-1906; Mgr. of Wks.. Walworth Mfg. Co., and *for mail*, 53 M St., South Boston, Mass.

MEYER, C. Louis (Junior, 1909), Trussed Concrete Steel Co., Terminal Bldg., Dallas, Tex.

MORRISON, Clarke J. (1909), Mech. Engr., 191 N. Walnut St., East Orange, N. J.

NILES, Francis H. (Associate, 1907), 5437 Cornell Ave., Chicago, Ill.

OATELY, Henry Bigelow (1910), Mech. Engr., Locomotive Superheater Co., 30 Church St., New York, N. Y.

PARISH, Wm. F. (1902; 1904), The Texas Co., 17 Battery Pl., New York, N. Y.

POTTS, S. Warren (1909), Mech. Engr., R. Hoe & Co., 504 Grand St., and *for mail*, 622 W. 135th St., New York, N. Y.

PRESSINGER, W. P. (Associate, 1903), Mgr. Compressor Dept., Chicago Pneumatic Tool Co., 50 Church St., and Orleans Hotel, 100 W. 80th St., New York, N. Y.

RIDGELY, William B. (1880; 1895), Pres., Witherbee Igniter Co., Springfield, Mass.

ROBBINS, Percy Arthur (Associate, 1901), Hollinger Gold Mines, Auva Lake P. O., Porcupine, Ont., Canada.

ROBESON, Anthony Maurice (1895), care A. Moir, 1 London Wall Bldgs., London, E. C., England.

ROTTER, Max (1899), Ch. Engr., Busch-Sulzer Bros.-Diesel Eng. Co., South Side Bank Bldg., St. Louis, Mo.

SHIPLEY, Grant B. (Associate, 1907), Pres. and Genl. Mgr., Pittsburg Wood Preserving Co., Pittsburg, Pa., and 477 Marshall St., Milwaukee, Wis.

WEEKS, Paul (Junior, 1905), 217 Mariposa Ave., Los Angeles, Cal.

WILLCOX, George Bingham (1895; 1908), Pres. and Genl. Mgr., Willcox Engrg. Co., Wilcox Engrg. Co. Bldg., and *for mail*, 900 S. Warren Ave., Saginaw, Mich.

WYMAN, Arthur H. (Junior, 1909), Sales Engr., Allis-Chalmers Co., and *for mail*, Flat 9, 227 13th St., Milwaukee, Wis.

NEW MEMBERS

ROSS, Sir Charles Henry A. F. L. (1910), Pres., Ross Rifle Co., Quebec, Canada.

ROSSMAN, James R., Jr. (Junior, 1910), Ch. Engr., Steel Cable Engrg. Co., Boston, and *for mail*, 1869 Beacon St., Brookline, Mass.

STEPHENS, Phinehas V. (1910), Constr. Dept., The Safety Insulated Wire & Cable Co., 114 Liberty St., New York, N. Y.

DEATHS

MASON, William B., February 4, 1911.

GAS POWER SECTION

CHANGES OF ADDRESS

AUE, Jos. E. (1908), Mem. Am. Soc. M.E.

BIBBINS, James Rowland (1908), Mem. Am. Soc. M.E.

DOW, Benjamin W. (Affiliate, 1909), Stone & Webster Engrg. Corp., 147 Milk St., Boston and *for mail*, 7 Standish St., Dorchester, Mass.

GARDNER, F. M. (Affiliate, 1910), Engr. and Salesman, Fairbanks, Morse & Co., and *for mail*, S. W. cor. 8th and Main Sts., Cincinnati, O.

HOPKINS, George Jay (Affiliate, 1909), Berlin Mch. Wks., 1125 Marquette Bldg., Chicago, and *for mail*, 230 S. Maple St., Sycamore, Ill.

LATTA, Nisbet (1908), Mem.Am.Soc.M.E.

MOSES, Percival R. (Affiliate, 1909), Cons. Engr., 366 Fifth Ave., New York, N. Y.

SHOOP, R. B. (Affiliate, 1908), Draftsman, Austin Mfg. Co., Harvey, and *for mail*, Blue Island, Ill.

STUDENT BRANCHES

CHANGES OF ADDRESS

BINNS, Geo. W. (Student, 1910), 347 McMillan Ave., Cincinnati, O.
BREER, Carl (Student, 1909), 5031 National Ave., West Allis, Wis.
BRONSON, C. E. (Student, 1910), 141 Seneca St., Hornell, N. Y.
BUTLER, N. R. (Student, 1909), 710 Thurston Ave., Ithaca, N. Y.
CASTRO, Pedro B. (Student, 1910), 332 W. College Ave., State College, Pa.
FRIED, J. A. (Student, 1910), 90 Waite Ave., Ithaca, N. Y.
GRENOBLE, H. S. (Student, 1909), 4312 Champlain Ave., Chicago, Ill.
HAM, C. W. (Student, 1910), 415 N. Cayuga St., Ithaca, N. Y.
HEBBARD, L. L. (Student, 1910), 713 W. Dayton St., Madison, Wis.
HELWIG, Alfred (Student, 1910), 10th Ave. and 70th St., Brooklyn, N. Y.
JACOBSEN, C. H. (Student, 1910), 5031 National Ave., West Allis, Wis.
JENKINS, Harold B. ((Student, 1910), 16 Morningside Ave. E., New York.
KOWALEWSKI, A. J. (Student, 1910), 316 Main Bldg., State College, Pa.
LINDSAY, H. D. (Student, 1909), 258 Farwell Ave., Milwaukee, Wis.
MANSFIELD, W. M. (Student, 1909), Woodhull, Ill.
NIXDORFF, S. P. (Student, 1909), 194 Jay St., Schenectady, N. Y.
PARMLEY, H. M. (Student, 1910), 507 N. Aurora St., Ithaca, N. Y.
PEACH, P. L. (Student, 1909), 708 E. Seneca St., Ithaca, N. Y.
PEASLEE, W. (Student, 1910), 2539 Stratford Ave., Cincinnati, O.
PEMBERTON, Carlysle (Student, 1909), 619 N. James St., Rome, N. Y.
QUICK, R. L. (Student, 1909), 141 Washington St., Hartford, Conn.
RUEF, John (Student, 1911), 6044 Michigan Ave., Chicago, Ill.
SCHUSTER, George (Student, 1909), 313 Quincy St., Topeka, Kan.
SPONSLER, J. M. (Student, 1909), 109 John St., Champaign, Ill.
STEUDEL, Geo. E. (Student, 1910), 229 W. Gilman St., Madison, Wis.
STRAYER, T. Franklin (Student, 1910), 233 McAllister Hall, State College, Pa.
TEMPLIN, E. W. (Student), 1910, Univ. of Maine, Orono, Me.
WATROUS, Russell W. (Student, 1910), 558 Ashland Ave., St. Paul, Minn.
WATSON, H. L. (Student, 1910), 452 Cascadilla Pl., Ithaca, N. Y.
WHAREN, Geo. B. (Student, 1910), P. R. R. Sch. for Apprentices, Altoona, Pa.
WOOD, Stanley V. (Student, 1909), Bachelor Hall, Wilkinsburg, Pa.
YOAKUM, F. E. (Student, 1909), 78 Sheldon Court, Ithaca, N. Y.

NEW MEMBERS

ARMOUR INSTITUTE OF TECHNOLOGY

STRALE, Nels (Student, 1911), 1533 E. 65th St., Chicago, Ill.

COLUMBIA UNIVERSITY

GREF, W. H. (Student, 1911) 21 Claremont Ave., New York.

CORNELL UNIVERSITY

ATKINSON, K. (Student, 1911), Cascadilla Bldg., Ithaca, N. Y.
CHAPMAN, W. H. (Student, 1911), 116 Lake St., Ithaca, N. Y.
CLARK, E. (Student, 1911), 103 Catherine St., Ithaca, N. Y.
DAVIS, F. (Student, 1911), 706 E. Buffalo St., Ithaca, N. Y.
DOLL, W. E. (Student, 1911), 603 E. Seneca St., Ithaca, N. Y.
EASTWOOD, S. K. (Student, 1911), 120 Catherine St., Ithaca, N. Y.
GARNER, H. H. (Student, 1911), 325 Dryden Rd., Ithaca, N. Y.
HAMANT, M. J. (Student, 1911), 206 College Ave., Ithaca, N. Y.
HAY, E. H. (Student, 1911), 528 Stewart Ave., Ithaca, N. Y.
HENDRICKSON, G. S. (Student, 1911), 206 Dryden Rd., Ithaca, N. Y.
HICKOK, J. P. (Student, 1911), 317 College Ave., Ithaca, N. Y.
HUNT, C. W. (Student, 1911), 109 E. Seneca St., Ithaca, N. Y.
McELROY, R. C. (Student, 1911), 206 College Ave., Ithaca, N. Y.
MORROW, C. H. (Student, 1911), 205 Dryden Rd., Ithaca, N. Y.
MILLS, S. D. (Student, 1911), 127 Dryden Rd., Ithaca, N. Y.
MORSE, R. V. (Student, 1911), 512 Edgewood Pl., Ithaca, N. Y.
VERY, W. R. M. (Student, 1911), 119 Stewart Ave., Ithaca, N. Y.
WALLACE, F. R. (Student, 1911), 510 E. Seneca St., Ithaca, N. Y.
WHEELER, H. T. (Student, 1911), 317 College Ave., Ithaca, N. Y.
WICK, L. T. (Student, 1911), 73 Sheldon Courts, Ithaca, N. Y.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DREW, W. N. (Student, 1911), 201 Magnolia St., Roxbury, Mass.

OHIO STATE UNIVERSITY

ALLEN, L. E. (Student, 1911), 2036 N. High St., Columbus, O.
BECKBERGER, E. H. (Student, 1911), 155 W. 10th Ave,. Columbus, O.
BERK, E. R. (Student, 1911), 1500 Neil Ave., Columbus, O.
BIGGERT, E. F. (Student, 1911), 355 King Ave., Columbus, O.
BORNHORST, A. H. (Student, 1911), 355 King Ave., Columbus, O.
COCHRAN, R. E. (Student, 1911), 83 W. Lane Ave., Columbus, O.
EMRICK, A. A. (Student, 1911), 105 W. Lane Ave., Columbus, O.
FOSTER, O. F. (Student, 1911), 397 N. Monroe Ave., Columbus, O.
FRANCE, L. E. (Student, 1911), 747 Franklin Ave., Columbus, O.
GRIFFIN. F. S. (Student, 1911), 185 W. 9th Ave., Columbus O.
HATFIELD, G. D. (Student, 1911), 175 W. 10th Ave., Columbus, O.
HOPKINS. A. L. (Student, 1911), 185 W. 9th Ave., Columbus, O.
HYATT, Edw. (Student, 1911), 212 E. Frambes Ave., Columbus, O.
LIEBICH, A. T. (Student, 1911), 75 W. 10th Ave., Columbus, O.
LOK, K. H. (Student, 1911), 155 W. 10th Ave., Columbus, O.

McCLELLAND, C. C. (Student, 1911), 28 12th Ave., Columbus, O.
OWEN, R. D. (Student, 1911), 323 Linwood Ave., Columbus, O.
PAPE, L. R. (Student, 1911), 1576 Neil Ave., Columbus O.
PERKINS, L. A. (Student, 1911), 1321 Highland St., Columbus, O.
POHLMAN, I. H., Student, 1911), 57 W. 10th Ave., Columbus, O.
SHULER, H. A. (Student, 1911), 1500 Neil Ave., Columbus, O.
STIEHL, C. E. (Student, 1911), 1500 Neil Ave., Columbus, O.

PENNSYLVANIA STATE COLLEGE

ANNE, G. E. (Student, 1911), Frazier St., State College, Pa.
MORRISON, C. R. (Student, 1911), 312 Main Bldg., State College, Pa.

RENSSELAER POLYTECHNIC INSTITUTE

STUART, Milton C. (Student, 1911), R. P. I. Dormitory, Troy, N. Y.
SWAIN, Donald, B. (Student, 1911), 29 Park Ave., Troy, N. Y.

UNIVERSITY OF ARKANSAS

HAYS, C. W. (Student, 1911), 101 N. West St., Fayetteville, Ark.

UNIVERSITY OF ILLINOIS

BOYLE, Clarence, Jr., (Student, 1911), Taylor Iron & Steel Co. High Bridge, N. J.
DOUGLAS, R. T. (Student, 1911), 805 W. Illinois St., Urbana, Ill.,

UNIVERSITY OF KANSAS

KNERR, L. E. (Student, 1911), 1230 Oread Ave., Lawrence, Kan.

UNIVERSITY OF NEBRASKA

NOELTING, W. H. (Student, 1911), 1722 Q St., Lincoln, Neb.

UNIVERSITY OF WISCONSIN

BARNUM, C. T. (Student, 1911), 610 Langdon St., Madison, Wis.
ROBERTS, C. (Student, 1911), 620 State St., Madison, Wis.

YALE UNIVERSITY

AUSTIN, R. F. (Student, 1911), 135 Sheff. Vanderbilt, New Haven, Conn.
BEATTIE, J. J. (Student, 1911), 151 Sheff. Vanderbilt, New Haven, Conn.
CHILDS, W. St. C. (Student, 1911), 17 Hillhouse Ave., New Haven, Conn.
COONEY, L. S. (Student, 1911), 124 Prospect St., New Haven, Conn.
HYDE, T. R. (Student, 1911), 148 Grove St., New Haven Conn.
SCHMIDT, F. W. (Student, 1911), 107 Sheff. Vanderbilt, New Haven, Conn.
SELDEN, S. M. (Student, 1911), 124 Sheff. Vanderbilt, New Haven, Conn.
SWENSON, S. M. (Student, 1911), 133 College St., New Haven, Conn.
WINTON, L. B. (Student, 1911), 136 Canner St., New Haven, Conn.

COMING MEETINGS

April—May

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AIR BRAKE ASSOCIATION

May 23–26, annual convention, Auditorium Hotel, Chicago, Ill. Papers: Air Brake Instruction, Rating, T. Clegg, Geo. A. Wyman, H. H. Burns, H. A. Wahlert, T. F. Lyons; Brake Cylinders and Connections, H. A. Wahlert; Adequate Braking Power for Freight Cars, J. P. Kelly; Cost of Maintenance of Locomotive Brakes, W. P. Huntley; Running Triple Valves without Lubricant, L. Leonard; Fibre Stresses in Brake Gear Parts, G. O. Hammond; "PC" Equipment, W. V. Turner; Steel Pipe vs. Iron Pipe, J. R. Alexander; Recommended Practice, S. G. Down, G. R. Parker, H. A. Wahlert, N. A. Campbell, J. R. Alexander; Friction of New and Worn Brake Shoes on New and Worn Cast Wheels, A. S. Williamson; Breaking-in-two of Trains, S. H. Draper, P. J. Langan. Secy., F.M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION

May 22–26, annual convention, Pittsburg, Pa. Secy., Richard Moldenke, Wachtung, N. J.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

April 14, monthly meeting, 29 W. 39th St., New York. Secy., R. W. Pope.

AMERICAN SOCIETY OF CIVIL ENGINEERS

April 5, 19, bi-monthly meetings, 220 W. 57th St., New York. Secy., C. W. Hunt.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Monthly meetings: April 11, 29 W. 39th St., New York; April 21, Boston, Mass.; April 22, Philadelphia, Pa. Spring Meeting, May 30–June 2, Pittsburg, Pa. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN RAILWAY INDUSTRIAL ASSOCIATION

May 9–10, annual meeting, Detroit, Mich. Secy., Guy L. Stewart, 1328 Pierce Bldg., St. Louis, Mo.

CANADIAN FREIGHT ASSOCIATION

April 13, annual meeting, Montreal, Que. Secy., T. Marshall, Toronto, Ont.

CONGRESS OF TECHNOLOGY

April 10-11, Massachusetts Institute of Technology, Boston, Mass.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

May 23–26, annual convention, Omaha, Neb. Secy., Harry D. Vought, 95 Liberty St., New York.

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS

April 12–13, annual meeting, Mass. Inst. of Tech., Boston, Mass. Papers: Arbitration on Cancellation of Orders, By-Products in Cotton Manufacture, Doffing Machines and their Relation to Child Labor, Electric Power Transmission to Cotton Mills, Executive Management of the Textile Plant and its Relation to the Market, Gas Producers and Gas Engines for Cotton Mills, Illumination, Law of Moisture in Cotton and Wool, Methods of Cost Finding in Cotton Mills, Moisture in Cotton, Renaissance of the Waterfall, Rewinding Weft Yarn, Sandwich Island Cotton, Textile Education from a Manufacturing Standpoint, Weaving Shed Roof Construction. Secy., C. J. H. Woodbury, Mem.Am.Soc.M.E., P. O. Box 3672.

NATIONAL ELECTRIC LIGHT ASSOCIATION

May 29–June 2, annual convention, New York. Secy., T. C. Martin, 29 W. 39th St.

NATIONAL FIRE PROTECTION ASSOCIATION

May 23–25, annual meeting, New York. Secy., F. H. Wentworth, 87 Milk St., Boston, Mass.

NATIONAL METAL TRADES ASSOCIATION

April 12–13, annual convention, Hotel Astor, New York. Comr., Robert Wuest, New England Bldg., Cleveland, O.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

May 18-19, semi-annual meeting, Youngstown, O. Secy., Frank E. Sanborn, Ohio State University, Columbus, O.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
April			
6	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
11	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
13	Illuminating Engineering Society	P. S. Millar	8.00 p.m.
13	Institute of Operating Engineers	M. W. Rice	8.00 p.m.
14	American Institute of Electrical Engineers	R. W. Pope	8.15 p.m.
18	New York Telephone Society	T. H. Lawrence	8.15 p.m.
21	New York Railroad Club	H. D. Vought	8.15 p.m.
24	National Isolated Power Plant Association	E. Fieux	8.00 p.m.
26	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
May			
4	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
9	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
11	Illuminating Engineering Society	P. S. Millar	8.00 p.m.
11	Institute of Operating Engineers	M. W. Rice	8.00 p.m.
16	New York Telephone Society	T. H. Lawrence	8.15 p.m.
16	American Institute of Electrical Engineers	R. W. Pope	8.15 p.m.
17	American Railway Association	W. F. Allen	10.00 a.m.
19	New York Railroad Club	H. D. Vought	8.15 p.m.
22	National Isolated Power Plant Association	E. D. Fieux	8.00 p.m.
24	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
30—June 2	National Electric Light Association	T. C. Martin	all day

OFFICERS AND COUNCIL

PRESIDENT

E. D. Meier...New York

VICE-PRESIDENTS

Charles Whiting Baker.................................New York
W. F. M. Goss ....Urbana, Ill.
Alex. C. Humphreys.....................................New York

Terms expire at Annual Meeting of 1911

George M. Brill..Chicago, Ill.
E. M. Herr...Pittsburg, Pa.
H. H. Vaughan ....Montreal, Can.

Terms expire at Annual Meeting of 1912

MANAGERS

H. L. Gantt...New York
I. E. Moultrop...Boston, Mass.
W. J. Sando..Milwaukee, Wis.

Terms expire at Annual Meeting of 1911

H. G. Stott...New York
James Hartness...Springfield, Vt.
H. G. Reist...Schenectady, N.Y.

Terms expire at Annual Meeting of 1912

D. F. Crawford...Pittsburg, Pa.
Stanley G. Flagg, Jr.......................................Philadelphia, Pa.
E. B. Katte..New York, N. Y.

Terms expire at Annual Meeting of 1913

PAST-PRESIDENTS

Members of the Council for 1911

Frederick W. Taylor.......................................Philadelphia, Pa.
F. R. Hutton..New York
M. L. Holman...St. Louis, Mo.
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TREASURER

William H. Wiley...New York

CHAIRMAN OF THE FINANCE COMMITTEE

Robert M. Dixon...New York

HONORARY SECRETARY

F. R. Hutton...New York

SECRETARY

Calvin W. Rice.........................29 West 39th Street, New York

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Alex. C. Humphreys, *Vice-Chairman*
Charles Whiting Baker
F. R. Hutton
H. L. Gantt
Jesse M. Smith

STANDING COMMITTEES

FINANCE

Robert M. Dixon (2), *Chairman*
Waldo H. Marshall (3)
Geo. J. Roberts (1)
H. L. Doherty (4)
W. L. Saunders (5)

HOUSE

Francis Blossom (2), *Chairman*
Edward Van Winkle (3)
Bernard V. Swenson (1)
H. R. Cobleigh (4)
S. D. Collett (5)

LIBRARY

Leonard Waldo (1), *Chairman*
Chas. L. Clarke (3)
W. M. McFarland (2)
Alfred Noble (4)
E. G. Spilsbury (5)

MEETINGS

L. R. Pomeroy (1), *Chairman*
H. de B. Parsons (3)
Chas. E. Lucke (2)
Willis E. Hall (4)
C. J. H. Woodbury (5)

MEMBERSHIP

Francis H. Stillman (1), *Chairman*
Hosea Webster (3)
George J. Foran (2)
Theo. Stebbins (4)
W. H. Boehm (5)

PUBLICATION

H. F. J. Porter (1), *Chairman*
Geo. I. Rockwood (3)
Fred R. Low (2)
Geo. M. Basford (4)
Chas. I. Earll (5)

PUBLIC RELATIONS

James M. Dodge, (5), *Chairman*
D. C. Jackson (2)
Robert W. Hunt (1)
J. W. Lieb, Jr. (3)
Fred J. Miller (4)

RESEARCH

W. F. M. Goss (3), *Chairman*
Ralph D. Mershon (2)
R. H. Rice (1)
Jas. Christie (4)
R. C. Carpenter (5)

Note.—Numbers in parentheses indicate number of years the member has yet to serve.

SPECIAL COMMITTEES
1911

On a Standard Tonnage Basis for Refrigeration

D. S. Jacobus
G. T. Voorhees
A. P. Trautwein
Philip De C. Ball
E. F. Miller

On Society History

John E. Sweet
Chas. Wallace Hunt
H. H. Suplee

On Constitution and By-Laws

Chas. Wallace Hunt, *Chairman*
F. R. Hutton
G. M. Basford
D. S. Jacobus
Jesse M. Smith

On Conservation of Natural Resources

Geo. F. Swain, *Chairman*
L. D. Burlingame
Charles Whiting Baker
M. L. Holman
Calvin W. Rice

On Identification of Power House Piping

H. G. Stott, *Chairman*
H. P. Norton
I. E. Moultrop
J. T. Whittlesey
F. R. Hutton

On International Standards for Pipe Threads

E. M. Herr, *Chairman*
Geo. M. Bond
William J. Baldwin
Stanley G. Flagg, Jr.

On Standards for Involute Gears

Wilfred Lewis, *Chairman*
E. R. Fellows
Hugo Bilgrim
C. R. Gabriel
Gaetano Lanza

On Power Tests

D. S. Jacobus, *Chairman*
L. P. Breckenridge
Edward F. Miller
Edward T. Adams
William Kent
Arthur West
George H. Barrus
Charles E. Lucke
Albert C. Wood

On Standardization of Flanges

A. C. Ashton
J. P. Sparrow
Wm. Schwanhausser
H. G. Stott

On Student Branches

F. R. Hutton, Honorary Secretary

Tellers of Election Officers and Members

Wm. T. Donnelly
Geo. A. Orrok
Theo. Stebbins

MEETINGS OF THE SOCIETY

THE COMMITTEE ON MEETINGS

L. R. Pomeroy, (1) *Chairman*
H. de B. Parsons (3)
Chas. E. Lucke (2)
Willis E. Hall (4)
C. H. J. Woodbury (5)

Meetings of the Society in Boston

Ira N. Hollis, *Chairman*
I. E. Moultrop, *Secretary*
Edward F. Miller
James D. Andrew
Richard H. Rice

Meetings of the Society in New York

Walter Rautenstrauch, *Chairman*
Fredk. A. Waldron, *Secretary*
F. H. Colvin
Edward Van Winkle
Roy V. Wright

Meetings of the Society in St. Louis

Ernest L. Ohle, *Chairman*
Fred E. Bausch, *Secretary*
M. L. Holman
R. H. Tait
John Hunter

Meetings of the Society in San Francisco

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University of Kansas, Lawrence, Kan.	March 9	P. F. Walker	W. H. Judy	L. L. Brown
New York Univ., New York City	November 9	C. E. Houghton	Harry Anderson	Andrew Hamilton
Univ. of Illinois, Urbana, Ill.	November 9	W. F. M. Goss	F. J. Schlink	E. J. Hasselquist
Penna. State College, State College, Pa.	November 9	J. P. Jackson	W. E. Heibel	G. M. Forker
Columbia University, New York City	November 9	Chas. E. Lucke	F. T. Lacy	J. L. Haynes
Mass. Inst. of Tech., Boston, Mass.	November 9	Gaetano Lanza	Morell Mackenzie	Foster Russell
Univ. of Cincinnati, Cincinnati, O.	November 9	J. T. Faig	H. B. Cook	C. J. Malone
Univ. of Wisconsin, Madison, Wis.	November 9	H. J. B. Thorkelson	F. B. Sheriff	L. F. Garlock
Univ. of Missouri, Columbia, Mo.	December 7	H. Wade Hibbard	F. T. Kennedy	Osmer N. Edgar
Univ. of Nebraska, Lincoln, Neb.	December 7	C. R. Richards	W. J. Wholenberg	W. H. Burleigh
	1910			
Univ. of Maine, Orono, Me.	February 8	Arthur C. Jewett	A. H. Blaisdell	W. B. Emerson
Univ. of Arkansas, Fayetteville, Ark.	April 12	B. N. Wilson	W. Q. Williams	H. W. Barton
Yale University, New Haven, Conn.	October 11	L. P. Breckenridge	ClaytonDuBosque	W. Roy Manny
Rensselaer Poly. Inst., Troy, N. Y.	December 9	A. M. Greene, Jr.	G. K. Palsgrove	H. J. Parthesius
	1911			
State Univ. of Ky., Lexington, Ky.	January 10	F. P. Anderson	G. C. Mills	H. L. Moore
Ohio State University, Columbus, O.	January 10	W. T. Magruder	H. A. Shuler	H. M. Bone
Washington, Univ., St Louis, Mo.	March 10			F. E. Glasgow

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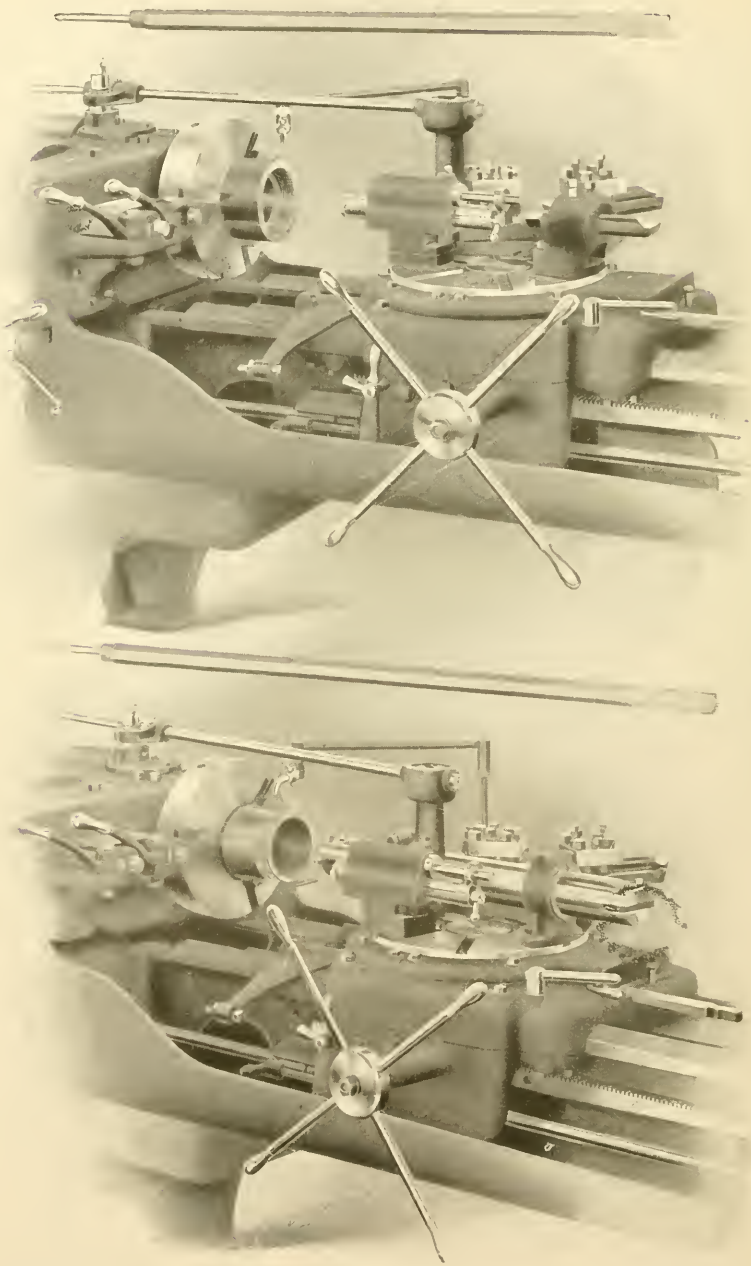

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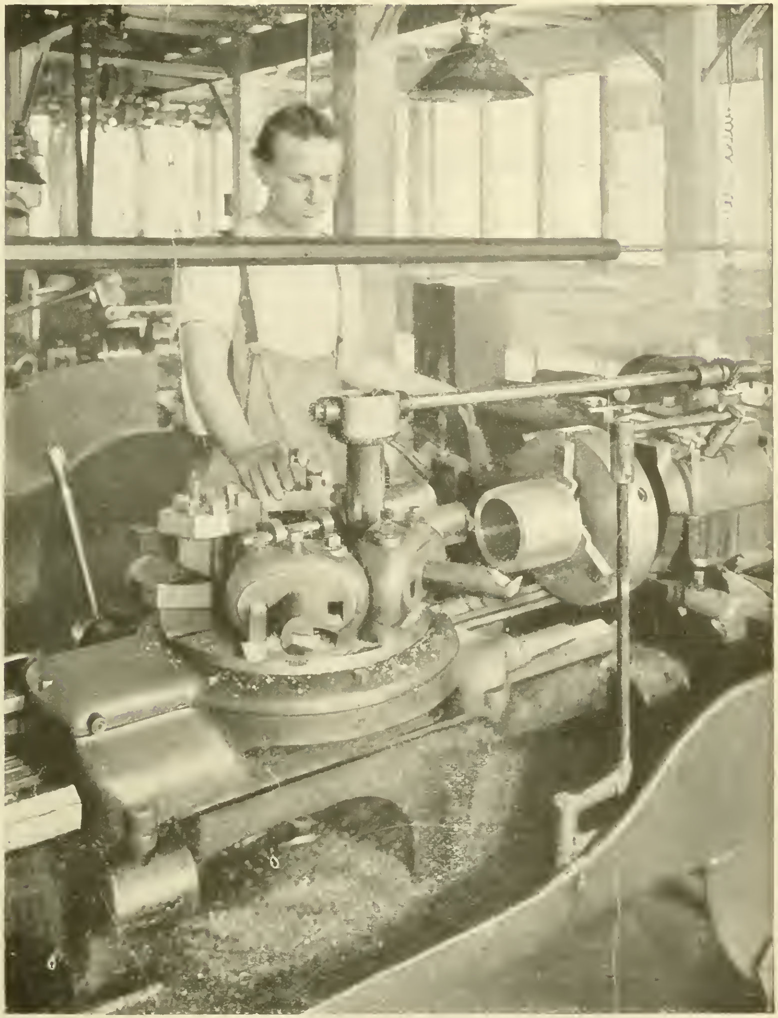

These three views of the chasing tool show its use for three different kinds of work. In the top picture on opposite page it is cutting an inside screw thread and the lower cut illustrates the tool in position for chasing an outside thread.

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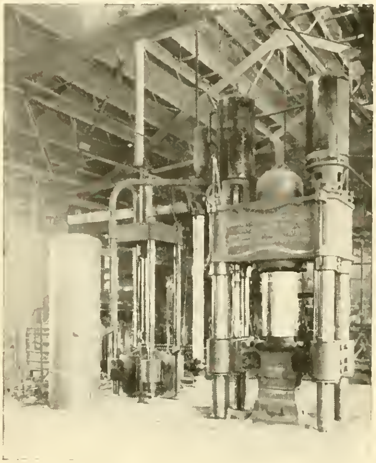

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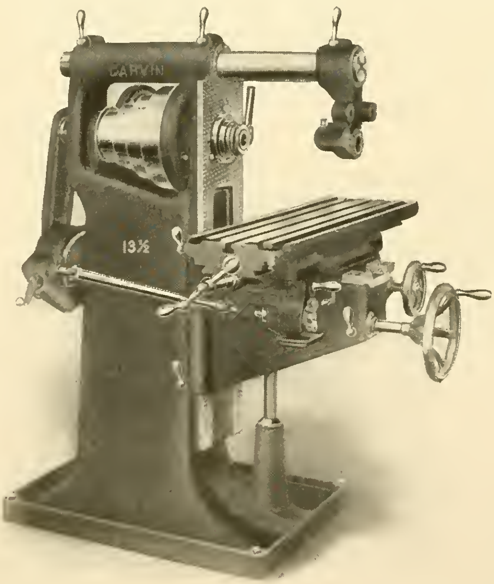

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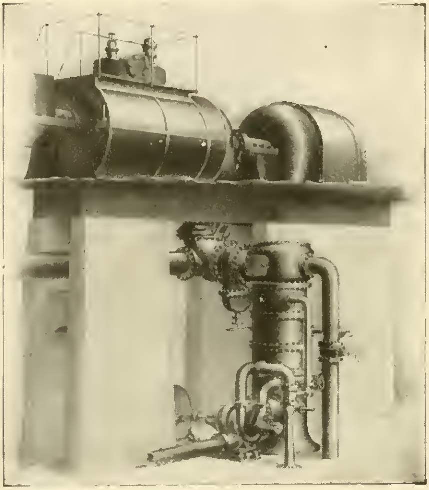

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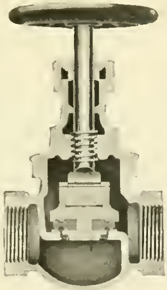

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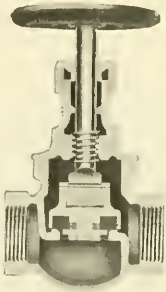

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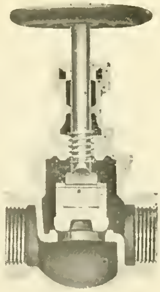

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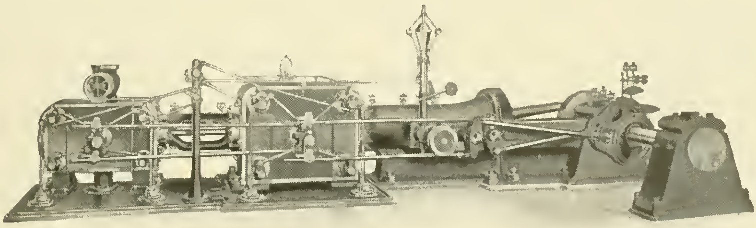

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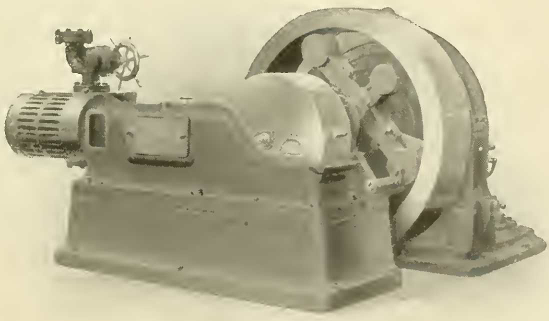

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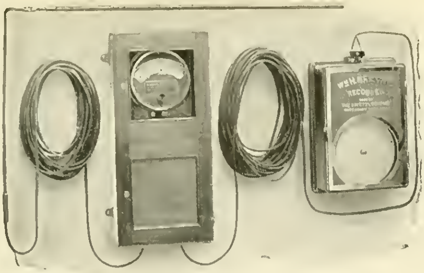

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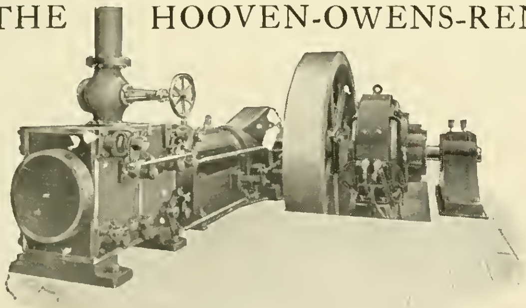

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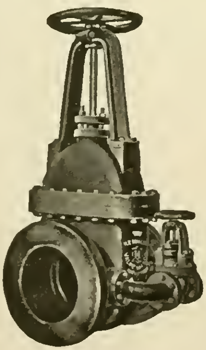

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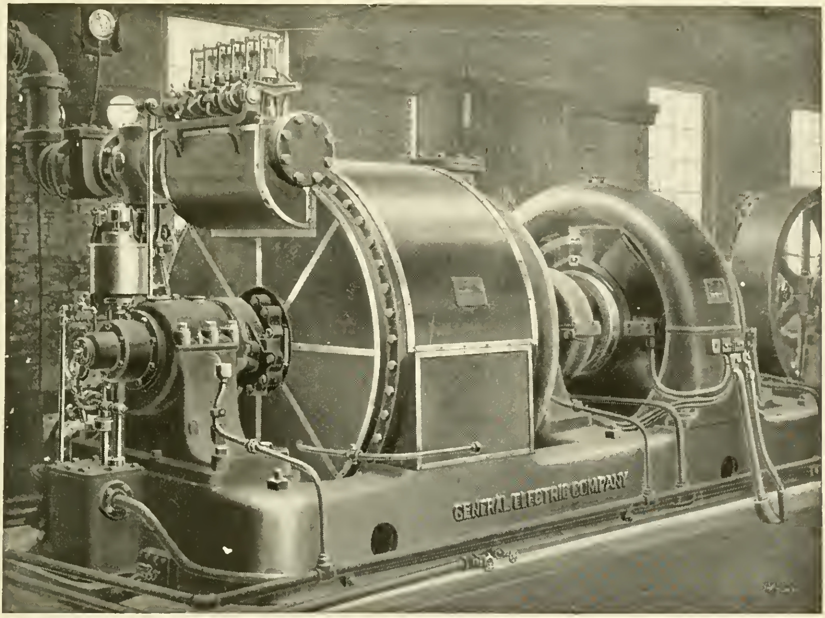

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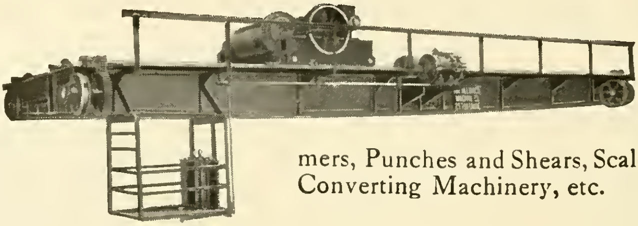

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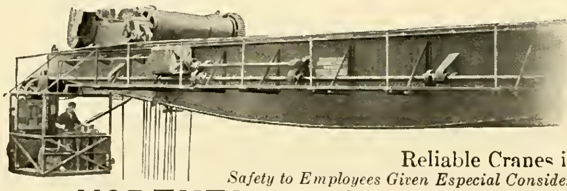

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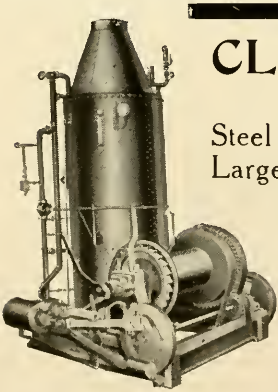

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Power Plant Equipment

Other sections of the Condensed Catalogues to be published in subsequent issues of The Journal will include Hoisting and Conveying Machinery, Power Transmission, Machine Shop and Foundry Equipment, Rolling Mill Machinery, Pumping Machinery, Mining and Metallurgical Equipment, Heating and Ventilating Apparatus, Refrigerating Machinery, Air Compressors and Pneumatic Tools.

THE AMERICAN SOCIETY *of* MECHANICAL ENGINEERS

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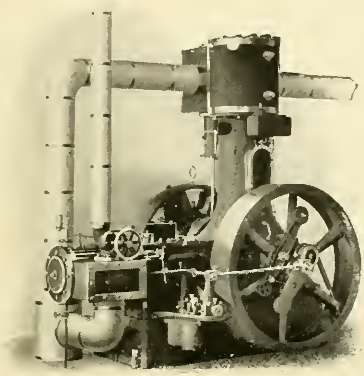
ALL KINDS OF HIGH GRADE SIMPLE AND COMPOUND STEAM ENGINES, DIRECT-CONNECTED UNITS, MOTORS AND GENERATORS.

THE AMERICAN-BALL ANGLE COMPOUND ENGINE



The American-Ball Angle Compound Engine has all of the advantages possessed by every American Engine, such as automatic system of lubrication, sensitive balanced automatic governor, adjustable cross head guides, attached indicator reducing motion, high-class workmanship, etc. Besides these, some of the special advantages inherent to the angle construction, are as follows:

(1) With the cylinders at right angles, practically perfect balancing is secured.

(2) The angle construction, with its four impulses per revolution, gives a practically uniform torque, making this engine especially adaptable for driving alternators which are to be run in parallel.

(3) With no dead centers, the engine can be started from any position.

(4) Small floor space. The Angle Compound Engine gets twice as much power on the same amount of floor space as does a simple engine.

These matters are fully discussed, with appropriate diagrams, in our pamphlet on "The Modern High-Speed Automatic Engine."

DIMENSIONS OF AMERICAN-BALL ANGLE COMPOUND ENGINES

FOR BELTED SERVICE								FOR DIRECT-CONNECTED SERVICE								
Horsepower	Cylinder Diameters and Stroke	Revolutions per Minute	Floor Space Length	Floor Space Width	Steam and Exhaust Pipes Steam	Steam and Exhaust Pipes Ex-haust	Shipping Weight Pound	K. W.	Cylinder Diameters and Stroke	Revolutions per Minute	Floor Space Length	Floor Space Width	Steam and Exhaust Pipes Steam	Steam and Exhaust Pipes Ex-haust	Shipping Weight in Pounds Direct Con-nected Engine	Shipping Weight in Pounds Engine and Dynamo
120	12 & 19 x 10	325	103	85	4	6	12,000	75	12 & 19 x 10	325	103	107½	4	6	12,200	17,000
160	13 & 20 x 11	300	111	93½	4	7	14,900	100	13 & 20 x 11	300	111	112	4	7	15,200	21,100
250	16 & 25 x 12	285	125	110	6	9	23,000	150	16 & 25 x 12	285	125	120½	6	9	21,400	32,200
325	18 & 28 x 14	260	138	126	6	10	30,000	200	18 & 28 x 14	260	138	132½	6	10	27,900	40,000
400	20 & 32 x 15	250	145	141	7	12	37,600	250	20 & 32 x 15	250	145	156½	7	12	31,700	45,000
500	22 & 34 x 16	240	154	158	8	12	45,000	300	22 & 34 x 16	240	154	165	8	12	39,200	
650	25 & 38 x 18	225	164	182	9	14	59,000	400	25 & 38 x 18	225	164	174	9	14	51,000	

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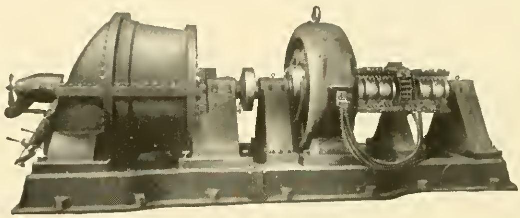
RATEAU-SMOOT LOW PRESSURE TURBINE; TANDEM COMPOUND CORLISS VALVE ENGINE; SIMPLE CORLISS AND SINGLE VALVE ENGINES; "BALL-WOOD" WELDED FLANGES FOR PIPES; CURVED AND BENT PIPE.

RATEAU-SMOOT LOW PRESSURE TURBINE

The Rateau-Smoot Low Pressure Turbine with generator, as illustrated below, uses exhaust steam between the limits of atmospheric pressure and vacuum produced by condenser. It is an impulse type turbine, the entire expansion of the steam taking place in the fixed vanes and by this method increasing the immunity against blade stripping.



Condensed Specification for the Rateau-Smoot Low Pressure Turbine:

Casing of high-grade cast iron tested after machining and assembling.

Rotors of high-grade steel machined and carefully balanced.

Buckets of special non-corrosive, non-erosive material. Each bucket is complete in itself and is mounted independently of all other buckets, thus eliminating entirely the necessity for any shroud ring.

Diaphragms located between the wheels are of cast iron or cast steel, in halves, carefully machined. Leakage between these cells can only occur between the diaphragm and shaft and this loss must be reduced to a minimum owing to the small clearance and the centrifugal tendency of the steam.

Guide Vanes are of special material adapted to resist corrosion and erosion.

Stuffing Boxes which seal against leakage the clearance between shaft and either end of the casing are arranged with carbon block linings which automatically take up their own wear.

Shaft of extra quality acid open hearth steel.

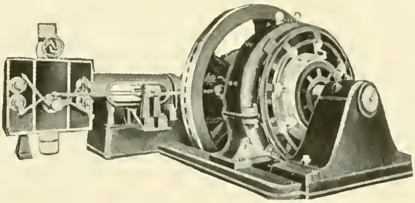
Governor is mounted directly on an extension of turbine shaft and controls steam admission by a positive solid mechanical connection.

Governor Valve is connected to balanced throttle valve of double seat, poppet valve type. The governor valve discharges the steam through a housing supporting the high-pressure bearing. This housing is designed in such a way as to allow the incoming steam to reach the first set of nozzles through a suitably designed chamber. The reversal of the direction of the flow of steam is thus brought about under the most favorable conditions.

Coupling which connects the turbine and generator consists of two hubs mounted one on each shaft. The torsional effect of machine is transmitted by pins which interline them and allow smooth operation to occur, even should the shafts be materially out of line.

The D. C. and A. C. Generators which we build and furnish, if desired, in connection with turbine are designed upon the most approved lines. Specification for these will be found in our catalog of turbines.

SIMPLE SINGLE-VALVE STEAM ENGINE



The Simple Single-Valve Steam Engine, direct connected to generator, is a perfect machine, running silently, smoothly and at small cost for maintenance. Duplicate parts are kept in stock to meet any demand and save vexatious delays. These engines are used under widely varied conditions and for very many purposes other than driving electric generators.

SIMPLE ENGINE (SINGLE VALVES)
Horizontal Direct-Connected Type
Table of Approximate Dimensions

Engine			Size of Generator K. W.	Revolutions per Minute	Approximate Floor Space		Diam. Wheels Inches	Diam. Steam Pipe Inches	Diam. Exhaust Pipe Inches
No.	Horse Power	Stroke Inches			Width	Length			
2	40	10	25	290–325	6′ 10″	8′ 4″	48	3	4
4	50	10	30	280–320	7′ 1″	8′ 7″	48	3	4
6	65	11	40	280–320	8′ 0″	9′ 0″	48	3½	4
8	80	11	50	275–310	8′ 8″	9′ 6″	54	4	5
11	115	12	75	265–290	9′ 8″	10′ 3″	66	5	6
13	150	14	100	250–275	10′ 8″	11′ 8″	72	6	7
15	180	16	125	225–250	11′ 1″	13′ 0″	72	6	7
16	225	16	150	215–235	12′ 1″	13′ 7″	84	7	8
16a	300	16	200	200–230	12′ 9″	13′ 8″	84	8	10
21	375	18	250	180–200	13′ 8″	15′ 6″	90	8	10

TANDEM COMPOUND ENGINES (CORLISS VALVES)
Horizontal Side-Crank Direct-Connected Type
Table of Approximate Dimensions

Engine			Size of Generator K. W.	Revolutions per Minute	Approximate Floor Space		Diam. Wheels Inches	Diam. Steam Pipe Inches	Diam. Exhaust Pipe Inches
No.	Horse-power	Stroke Inches			Width	Length			
231	150	16	100	250	11′ 3″	17′ 10″	78	4½	7
232	175	18	125	225	11′ 8″	18′ 5″	84	4½	8
233	225	18	150	225	12′ 2″	18′ 9″	84	5	8
234	250	20	175	210	13′ 0″	19′ 8″	90	5	9
235	300	24	200	200	14′ 0″	22′ 10″	96	6	9
243	300	27	200	150	14′ 5″	23′ 11″	108	6	9
237	375	24	250	200	14′ 6″	23′ 0″	96	6	10
238	375	27	250	150	15′ 0″	25′ 2″	120	6	10
239	450	27	300	150	16′ 4″	25′ 10″	132	7	10
240	525	27	350	150	16′ 6″	25′ 10″	132	7	12
244	600	24	400	200	15′ 10″	23′ 7″	96	8	12
241	600	30	400	150	18′ 3″	28′ 6″	132	8	12
245	600	36	400	125	18′ 5″	30′ 0″	144	8	12
246	750	30	500	150	18′ 8″	28′ 8″	132	8	14
247	750	36	500	125	18′ 11″	30′ 2″	144	8	14

"BALLWOOD" WELDED FLANGES

"Ballwood" Welded Flanges for steam, air, gas and hydraulic piping are made of the same metal as the pipe, insuring homogeneity in the weld. The pipe is specially prepared to receive the flange. The flange is put on rough and turned to standards after welding in special furnaces by special machinery. Every class of facing for special or standard sizes of flange may be had cut to diagram. We are prepared to furnish flanged pipe from 2″ up to 30″ diam.

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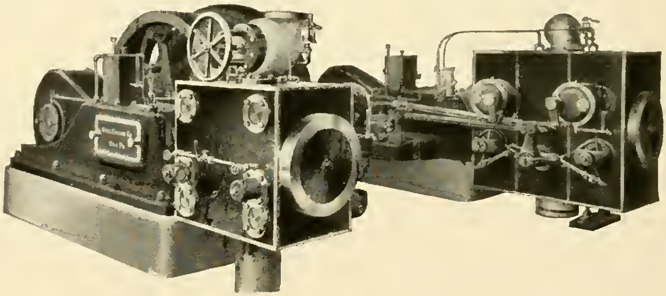
CORLISS-VALVE AND SINGLE-VALVE ENGINES; HORIZONTAL AND VERTICAL SIDE-CRANK ENGINES; TANDEM AND CROSS-COMPOUND SINGLE-VALVE ENGINES, CORLISS-VALVE COMPOUND AND SINGLE-CYLINDER ENGINES.

HIGH-SPEED CORLISS ENGINES

The feature which distinguishes this engine from other four-valve shaft governed engines is the patented non-detaching valve gear, which imparts the same movement to the valves that the drop cut-off of the slow-speed Corliss produces by picking up and dropping them. This permits the use of the best form of valve, and the valves are given the movement necessary for the greatest durability and tightness.

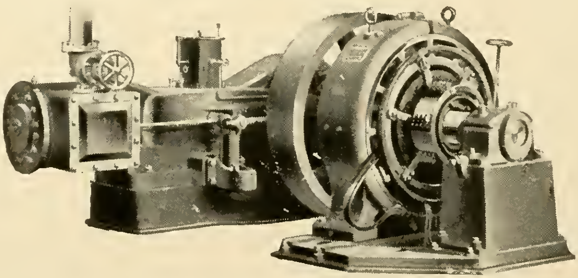
Built in sizes from 100 h.p. to 1200 h.p. in the single-cylinder and cross-compound types.

These engines excel in economy and regulation and are especially adapted for electric service.



SINGLE-VALVE AUTOMATIC ENGINES

These engines are the result of a long experience in building engines for electric service. They are superior in design and construction. The regulation and economy are the best of their type.

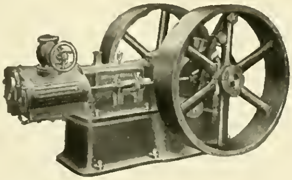


Built in sizes from 25 h.p. to 800 h.p. in the single-cylinder, tandem-compound and cross-compound types.

BUFFALO FORGE COMPANY

BUFFALO, N. Y.

BUFFALO ENGINES, HORIZONTAL, VERTICAL, SIMPLE, COMPOUND, SIDE AND CENTER CRANK; "B" VOLUME BLOWERS AND EXHAUSTERS; STEEL PLATE FANS

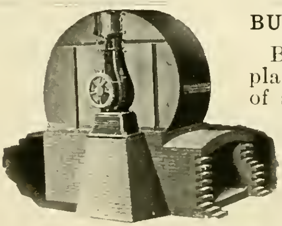


BUFFALO ENGINES

Balanced Piston Valves, Bored Guides, Crank Shaft of one piece forged open hearth steel with counterbalance weights, Inertia Shaft Governor. Bath or Sight Feed lubrication, Forged or Cast Steel Connecting Rod, cylinder and valve chest of one piece close-grained grey iron. Close regulation, smooth quiet running, economical operation.

Buffalo Horizontal Simple Engines

H. P.	R. P. M.	Max. Kw.	Bore and Stroke, In.	Floor Space—In. Side Crank Length	Side Crank Width	Center Crank Length	Center Crank Width	Fly W. Dia. In.	Steam Pipe In.	Exhaust Pipe In.
20	450	10	6 x 6	66	42			33	2	2¼
45	400	20	8 x 8	76	48	73	40	39	2½	3
65	350	35	10 x 10	89	56	80	56	49	3	3½
95	300	50	12 x 12	110	64	110	60	57	4	5
135	270	75	12 x 14			126	70	66	4	5
200	270	100	15 x 14			130	77	66	5	6
285	225	150	16 x 16			144	88	72	6	7
350	200	200	18 x 18			161	95	84	7	8
Buffalo Horizontal Tandem Compound Engines										
65	400	35	7 & 12 x 8			112	56	49	2½	3½
95	375	50	9 & 16 x 10			138	60	57	3	5
135	300	75	10 & 18 x 12			152	70	57	4	6
200	275	100	11 & 18 x 14			180	77	66	4	7
200	275	120	12 & 20 x 14			180	77	66	5	7
285	225	150	14 & 22 x 16			198	88	72	6	9
350	185	200	17 & 28 x 18			204	95	84	7	10
Buffalo Vertical Engines, Classes "A" and "B"										
6	550	3	4 x 4			34	32	27	1¼	1½
12	475	6	5 x 5			37	34	31	1½	2
18	450	10	6 x 6			41	37	33	2	2½
18	425	10	7 x 7			41	37	33	2	2½
45	400	20	8 x 8			43	40	39	2½	3
65	350	35	10 x 10			52	52	49	3	3½
95	300	50	12 x 12			62	64	57	4	5



BUFFALO FAN SYSTEM OF FORCED DRAFT

Buffalo steel plate fans are made of heavy steel plate, rigidly braced by angle irons at every point of strain. The fan wheel is balanced, smooth and easy running. Large oil ring bearings of approved type are used. The scroll shaped housing is most efficient for handling large volumes of air. Engine, pulley or motor driven.

BUFFALO STEEL PLATE FANS

Speeds, Capacities (cu. ft. of air per min.) and Horse Power (Air at 50 deg. fahr.

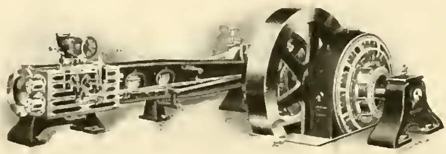
Size In.	Dia. Blast Wheel. In.	½ Oz. Pressure R.P.M.	Vol.	H.P.	1 Oz. Pressure R. P.M.	Vol.	H.P.	2 Oz. Pressure R. P.M.	Vol.	H.P.
40	29	481	2625	0.65	680	3710	1.84	960	5240	5.17
60	43	325	5920	1.46	459	8320	4.13	650	11800	11.66
80	57	245	10210	2.53	346	14450	7.15	488	20400	20.24
100	71	197	16610	4.11	278	23500	11.66	392	33200	32.78
120	85	164	24200	6.00	232	34300	17.05	328	48300	47.85
140	99	141	32800	8.14	199	46400	22.99	282	65500	64.79
160	113	121	43250	10.67	174	61100	30.00	247	86200	85.25
180	127	110	55000	13.64	155	77700	38.50	220	119500	118.25

THE FITCHBURG STEAM ENGINE CO.

FITCHBURG, MASS.

SINCE 1870 MANUFACTURERS OF STEAM ENGINES
FOR USE UNDER EVERY SORT OF CONDITION

"THE FITCHBURG"—DIRECT-CONNECTED—GIRDER BED

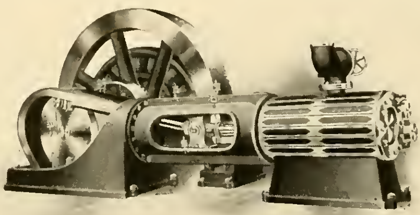


Sizes 7″ by 18″ to 22″ by 42″. Revolutions 80 to 250.

D. Con. or Belted	Girder Bed as above	To	300	H.P.
" " "	Tangye Bed as below	"	800	"
" " "	Tandem Girder	"	300	"
" " "	Tandem Tangye	"	800	"
" " "	Cross Girder	"	750	"
" " "	Cross Tangye	"	1500	"
" " "	High-Speed Horizontals	"	250	"
" " "	Single Cylinder Vertical	"	400	"
" " "	Steeple Comp'd Vertical	"	400	"

Details for any size given on application.

"THE FITCHBURG"—DIRECT-CONNECTED—TANGYE BED



Sizes 12″ by 18″ to 30″ by 48″. Revolutions 80 to 250.

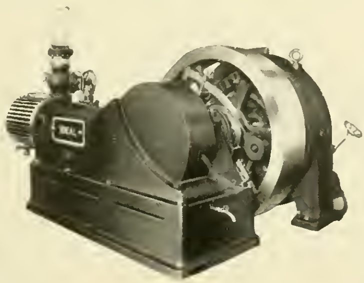
A. L. IDE & SONS

SPRINGFIELD, ILLINOIS

"IDEAL ENGINES" FOR ALL POWER PURPOSES

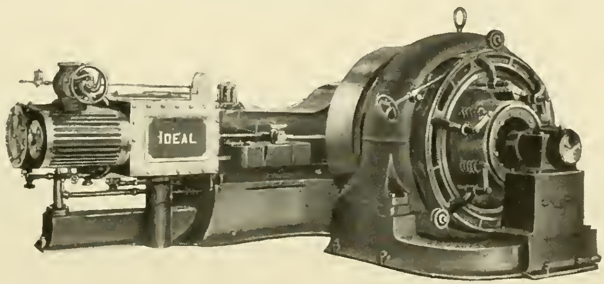
Ideal Engines are built in simple and compound types, the former in sizes of eight to four hundred horsepower and the latter from forty to five hundred horsepower. Peculiar to all Ideal Engines is an automatic system of lubrication in which there are no moving parts. Accurate and sensitive regulation is accomplished by the Armstrong Governor in which bearings under pressure have been eliminated. Each engine is completely self-enclosed, yet each moving part is easily accessible.

SIMPLE SIDE-CRANK ENGINE DIRECT-CONNECTED TO GENERATOR



This type is used principally for direct connection to either alternating or direct-current generators. It is, however, applicable to belted service by the substitution of a wide-face driving pulley for the electrical unit. Simple engines are furnished with either piston or flat balanced valves as required. The piston valve is recommended on account of its perfect balance and low cost of maintenance. The former characteristic is accomplished by making the valve hollow and consequently light in weight. For convenience both at time of installation and thereafter permanent arrangements have been made for checking alignment.

TANDEM-COMPOUND ENGINE DIRECT-CONNECTED TO GENERATOR



Among the notable characteristics of the Compound Engine illustrated above is compactness. As with the simple engine this type is primarily designed for electrical service; but this in no way precludes its use for belt connection to line shaft.

In all tandem compounds the high-pressure cylinder is placed in front of the low-pressure cylinder; two methods being employed in connecting them. In one the high-pressure cylinder is bolted directly to the low-pressure cylinder, in the other an extension piece is placed between the two cylinders and the high-pressure cylinder exhausts into a receiver. This receiver is unnecessary in the first method as the steam from the high-pressure cylinder passes directly into the steam chest of the low-pressure cylinder.

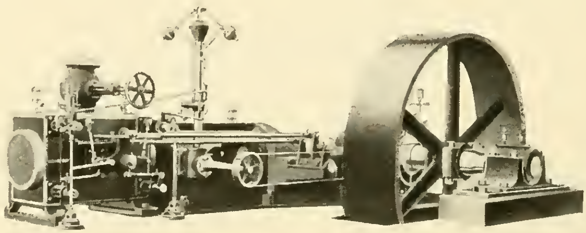
THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON, OHIO

CORLISS ENGINES, SLOW AND MEDIUM SPEED WITH RELEASING GEAR; CORLISS HIGH-SPEED ENGINES WITH NON-RELEASING GEAR; HIGH-DUTY PUMPING ENGINES; HAMILTON POWER PUMPS; AIR COMPRESSORS; FLEXIBLE COUPLINGS; SPECIAL HEAVY CASTINGS.

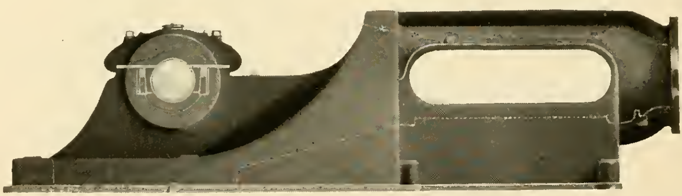
HAMILTON CORLISS, SERIES "E" HEAVY-DUTY, ONE-PIECE FRAME ENGINE

For Direct Connection to Generator or Belt Drive for Heavy Mill Service



Scientifically designed to meet the severest demands of modern practice; built for high steam pressure and greater rotative speed than customary, equipped with sensitive governor insuring close regulation. Every line suggests rigidity and stability.

Steam and exhaust passages in the cylinders are very large, permitting low steam velocities, indicator cards showing horizontal admission and exhaust lines; volummetric clearance small, reducing steam consumption. Steam and exhaust valve mechanisms are usually operated by separate eccentrics, giving long range cut-off. Valves are double ported and motion of all parts is reduced to a minimum. Ports are liberal and designed so as to give free and unobstructed passages for the steam, to and from the cylinder. All parts are made strong and compact, so that overhang is minimized.



Side View of One Piece Heavy Duty Frame

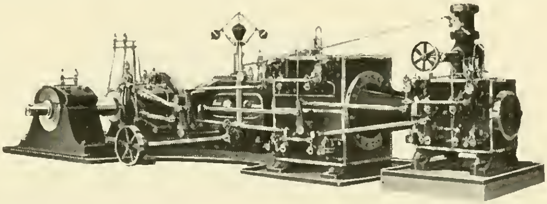
Frame is of the rolling mill type and cast in one piece; it has a broad footing on foundation for its entire length and extends around and under crank disc. Special tools have been installed in our works for machining these large castings at one setting, in order to insure perfect alignment.

Every detail of these engines receives great care and is fully described in our bulletins issued at frequent intervals.

The smallest engine of this class we build is 50 h.p., and there is no limit to the largest size consistent with modern practice. Our shops being thoroughly equipped, we are able to make quick delivery.

THE HOOVEN, OWENS, RENTSCHLER CO.

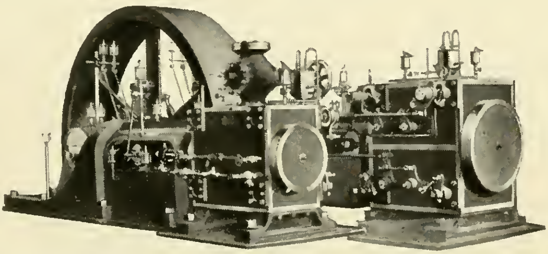
TANDEM-COMPOUND HAMILTON HIGH-SPEED CORLISS ENGINE



This engine is equipped with positive driven valve gear and link motion with variable speed hand regulating cut-off mechanism and is arranged for direct connection to centrifugal pump or blower. It is provided with a fly-ball governor, attached to quick closing butterfly valve.

The frame used on this engine is of same design as described on the previous page. The speed of this engine is usually from 125 to 175 r.p.m.

HAMILTON CORLISS CROSS-COMPOUND HIGH-SPEED CORLISS ENGINE



This engine is adapted for all speeds from 125 to 200 r.p.m. It is made from our regular Corliss patterns, with changes in the valve gears to meet the demand for higher speeds than are possible with the releasing gear and dash pots.

This engine is entirely in a class by itself and is different from the so-called "four-valve engine." The valve movement is as near the regular Corliss movement as it is possible to make, without a hook and dash pot release.

The mechanism is such that the valves move during the balanced period giving highest economy and least wear. The rocker arms, etc., are as light as possible, consistent with strength, reducing inertia forces to a minimum.

The valve stems are equipped with special spherical metallic packing of our own design (patented), thus eliminating the use of stuffing boxes. The entire valve gear sets close to the cylinder, reducing overhang to a minimum.

The governor used on this engine is of the Hunt Shaft Governor Type (patented), which is different from any other manufactured. It is arranged so that the governor weights, springs and eccentrics are in perfect gravity balance at all speeds, making it possible to equalize the steam distribution in each end of the cylinder. Another feature of importance is that the spring is attached to the weight in such a manner that its force and the centrifugal force of the weight are nearly opposite, making the resultant force and the wear on the weight pin very small indeed.

THE MURRAY IRON WORKS CO.

BURLINGTON, IOWA

BUILDERS OF CORLISS ENGINES; PUMPING ENGINES; AIR COMPRESSORS; FEED WATER HEATERS; BOILERS; AND CONTRACTORS FOR COMPLETE POWER PLANTS.

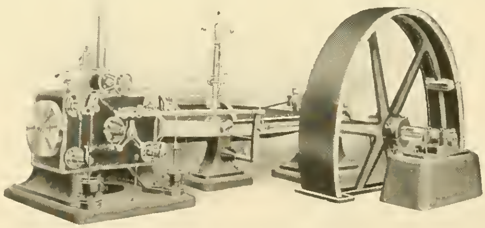
MURRAY CORLISS ENGINES

Murray Corliss Engines are built either with girder frames, tangye frames, or rolling mill frames of our patented design. The Standard Murray Corliss is a girder-frame engine built in capacities ranging from 50 to 600 indicated horsepower. Tandem and cross-compound engines are built for any load required.

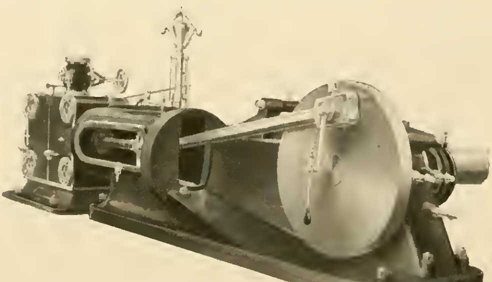
CONSTRUCTION DETAILS

Material and workmanship are of the best and inspection is most rigid at every stage of construction. Governor is of high-speed ball-bearing type, with improved safety stops. Cylinder has exhaust passages insulated from cylinder by dead air space. Valves, valve motion, dash pots and piston are all of improved patterns. Fly wheels made in halves, free from initial strains. Pillow block vertically adjustable with oil-retaining rim.

Broad pyramidal main bearing and cylinder feet or sole plates. Connecting rod and cross head are of improved pattern and the clearance volume has been reduced to a minimum. Many working parts are ground.



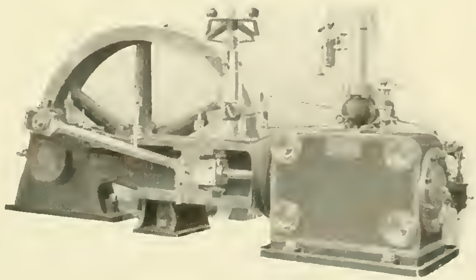
Standard Murray Corliss Engine



Murray Rolling Mill Type Engine

MURRAY-MINOR CORLISS ENGINE—20 to 50 H. P.

Suitable for day loads in small electric plants and for the smaller mills and factories

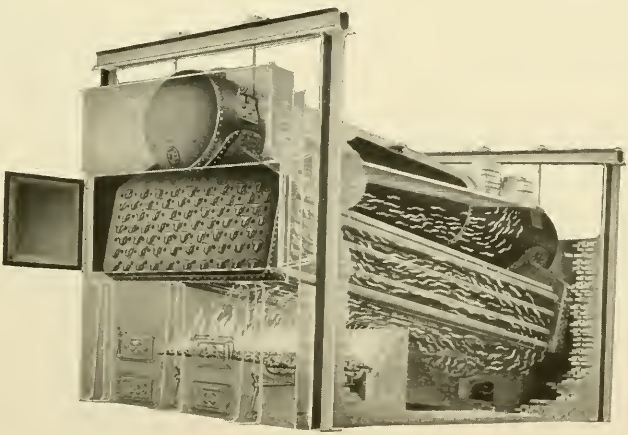


MURRAY SAFETY WATER TUBE BOILER

Our boiler consists of one or two top drums with front and rear headers all entirely constructed of boiler plate, with a number of wrought tubes connecting the headers. The drums incline to the rear, and headers are carefully and strongly riveted to drums, the tubes being expanded into both headers.

Free circulation of water and steam is provided for by having all connections of ample size. An internal mud drum is provided for removing impurities from the water, this drum being provided with necessary blow-off cocks. Our boilers are inspected and insured by boiler insurance companies.

The setting is designed upon proved lines of construction which an ordinary mason can execute properly. Murray rocking grates are furnished.



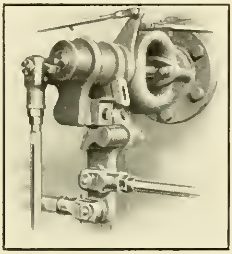
Murray Water Tube Boiler

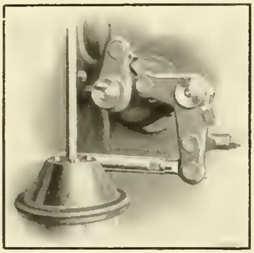
CONDENSED DESCRIPTION OF VALVE GEAR

RICE & SARGENT Releasing Gear is distinguished by the absence of wrist plate, hook rods, spring latches, etc., which are usual with wrist plate construction. The valves are operated by rods having a straight line motion. These rods are pivoted to the Valve Rockers. The valves are double and triple ported, depending upon the size of the engine, and ample port opening is obtained with a short movement of the valve.

Valve Rockers are made short so that the motion of the valve rod is also short, thus reducing wear and tear to a minimum and readily adapting the valve gear to speeds of revolution higher than suitable for the regular slow-speed Corliss Engines.

The Exhaust Valves are opened by a double movement which allows the valves to pause at the time the pressure upon them is greatest, thus minimizing the friction loss and giving a rapid motion at the time of opening and closing the ports.





The Steam Valves are operated by a separate eccentric from that operating the exhaust, this arrangement permitting a long range cut-off (80%) and perfect adjustment of compression and release not obtainable otherwise.

Connection Ends upon valve gear are of bronze with graduated wedge adjustments for taking up wear and maintaining the length of rod constant. The wedges have a full bearing surface upon the boxes with a safety device to prevent slip.

Dash Pots are of two types, Vacuum or Spring—both noiseless. Vacuum Pots are preferably limited to speeds of 125 revolutions per minute and Spring Pots for speeds up to 250 revolutions. Their strengths on normal lifts are the same. On light loads where a vacuum pot of the best design might not close properly, the spring pot, being positive in its action, would give results equally as good with heavier load.

SPEEDS

The Releasing Gear upon our Corliss Engines in sizes up to 1000 H.P. operates in a satisfactory manner at any speed up to 150 R.P.M. Smaller engines may be run as fast as 200 R.P.M and the larger sizes at suitably lower speeds. In all cases where either weight, space or first cost are of importance, the general advantage of running engines as fast as practicable is obvious, as by so doing the power required may be obtained from a smaller engine. Hence the modern tendency toward higher speeds of revolution and higher piston speeds. Many engineers are adverse to piston speeds as high as 900 ft. per minute, yet experience goes to show that such speeds are permissible and do not show excessive wearing tendency. High piston speeds are conducive to better steam economies, for the larger the volume of steam worked through a given cylinder per unit of time, the smaller the percentage of condensation therein.

MAIN FRAME

The Main Frame is of the heavy-duty or rolling-mill type. The complete frame is cast in one piece from the connection at the cylinder to and including the main pillow block and extends to the foundation throughout its entire length, including that portion under the crosshead guide.

ENGINES WITH NON-RELEASING GEAR

Engines of this type are intended for speeds of about 200 R.P.M. to about 250 R.P.M. according to size, but are furnished only for a comparatively small range of types and sizes.

TROY ENGINE & MACHINE CO.

TROY, PENNSYLVANIA

STEAM ENGINES OF THE CENTRE-CRANK TYPE EXCLUSIVELY.

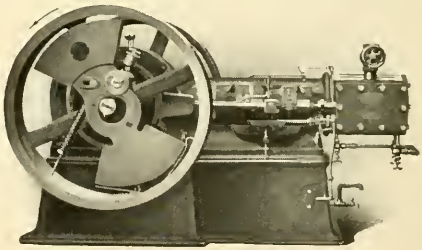
Our standard products are given in the list below. Column B gives the maximum usual pressure and Column C the number of sizes made.

Stock Title	B	C
Troy Vertical Automatic Engines	80–160	13
Troy Horizontal Automatic Engines	80–160	8
Troy Vertical Direct-Connected Engines	80–160	13
Troy Horizontal Direct-Connected Engines	80–160	8
Troy Vertical Throttling Engines	80–160	14
Troy Horizontal Throttling Engines	80–160	9
Troy Vertical Low-Pressure Engines	10– 40	10
Troy Horizontal Low-Pressure Engines	10– 40	6

All the above are made either enclosed and self-oiling, or open with gravity lubrication.

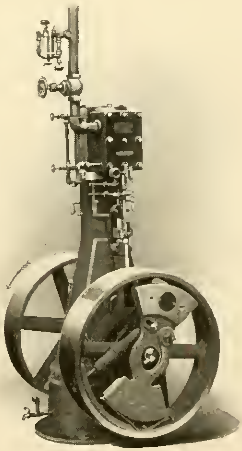
HORIZONTAL AUTOMATIC ENGINES

The Troy Horizontal Automatic Engine is massive, compact, and will resist perceptible spring regardless of load. It is of the centre-crank type and its working parts are identical with the vertical engine below. It has bored guides and overhanging cylinder. Lubrication for the principal bearings is supplied by the self-oiling system, which is positive in action, the circulation being under slight pressure. A sight feed shows the flow of oil. The crank pin is automatically oiled from the main bearing through the shaft.



Self-Oiling Type

TROY VERTICAL AUTOMATIC ENGINE



Self-Oiling Type

Troy vertical engines have cylinders fitted with cast iron lagging which forms an air space to reduce condensation. The heads require no packing.

The valve is simple, well balanced and will relieve the cylinder of water which may enter. It will never leak.

The piston is a single casting firmly secured to the rod so that it cannot become loose. Two packing rings are sprung into grooves to make it steam tight.

The cross-head has a large sliding surface of phosphor bronze, adjustable through a considerable range.

The connecting rod is of open-hearth steel with a length of six time the radius of the crank. The crank end is of the marine type, easily adjusted. The crank-pin bolts are fitted with an excellent nut locking device, providing unusual safety.

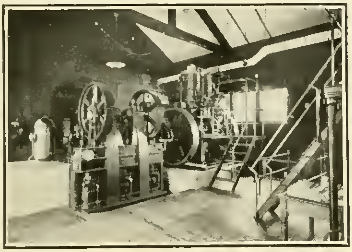
AUGUST MIETZ IRON FOUNDRY & MACHINE WORKS

123 MOTT ST., NEW YORK

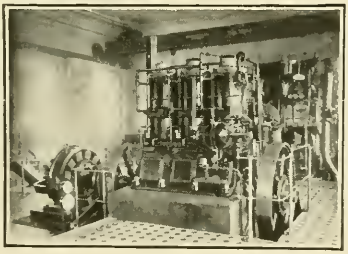
OIL ENGINES, MARINE AND STATIONARY, DIRECT COUPLED OR BELTED TO GENERATORS; AIR COMPRESSORS; PUMPS; HOISTS.

THE MIETZ & WEISS OIL ENGINES

Stationary and Marine, 2 to 600 h.p. Direct Reversible Marine Engines 75 to 600 h.p.

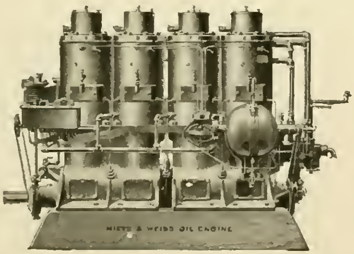


These engines are operated at moderate compression pressures and medium speeds, consuming approximately one gallon of crude oil or other fuel per ten horse-power hours, at a cost of three cents. The smaller sizes generally run with kerosene.



They are two-cycle heavy duty engines, extremely simple, and, equipped with our steam cooling system, the reliability and durability is equal to the modern steam engine. The steam generated in the water jacket of the cylinder enters the combustion space and is compressed with the charge.

They are used largely for factory, pumping and electric light plants, either direct or belted to generators, operating in parallel.



The Direct Reversible Marine Engines are rigidly connected to the propeller shaft, without fly wheel and fitted with the S & W Air Distributor. They are controlled by a lever to stop or start the engine in either direction by compressed air through most reliable and positive mechanism.

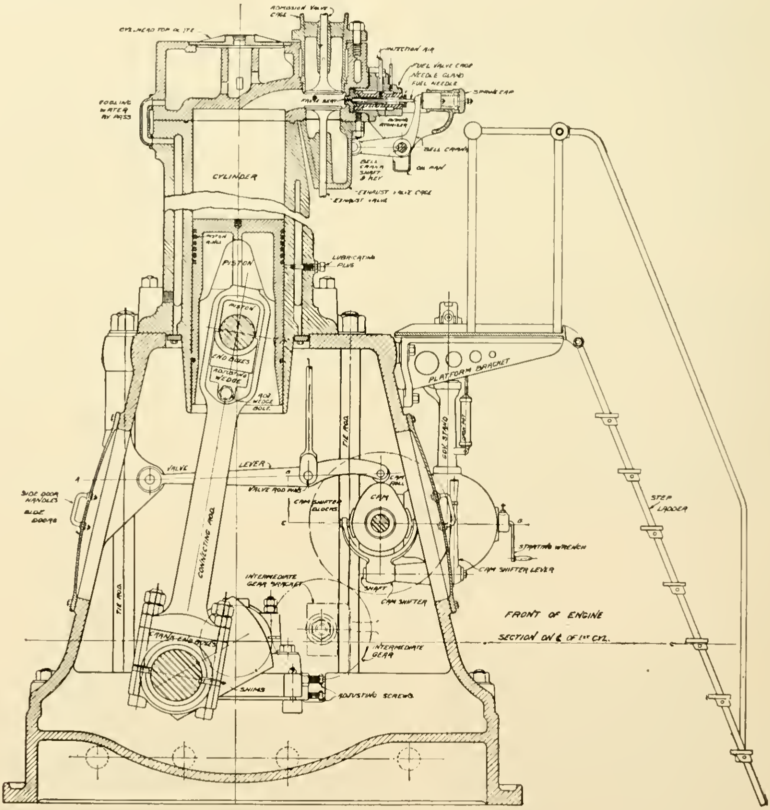
ADOLPHUS BUSCH OF ST. LOUIS, MO.

BY PURCHASE OF PATENTS AND PATENT RIGHTS
CONTROLS THE MANUFACTURE AND SALE OF ALL

AMERICAN DIESEL ENGINES

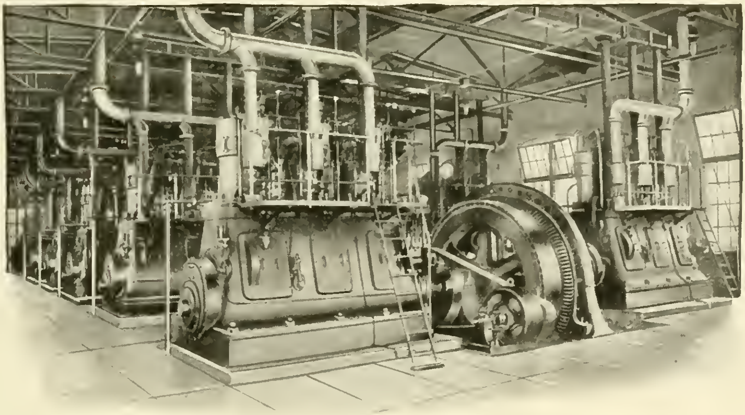
The Diesel Engine is designed for the use of Oil Fuels of low grades, such as crude oil or their residual products. The engine is of the vertical enclosed type. A small pump mounted on the engine delivers the fuel to the atomizing chamber, and a separate small air compressor of standard construction serves to inject the fuel and store air for starting.

The action is on the four stroke or Otto cycle. It differs from other internal combustion engines in compressing a full charge of air to a predetermined temperature above the igniting point of the fuel. When the compression stroke has been completed, this is blown by highly compressed air into the cylinder, ignites spontaneously without explosion solely from the heat of the air generated in compression and burns steadily with no essential rise in pressure, in this particular more nearly following the precedent of the steam engine. Speed regulation and fuel control is sensitive and complete.



Sectional View, Diesel Engine

The main working parts shown above are of standard design and up to the best practice and workmanship. The cylinder, cylinder head and fuel valve are all thoroughly cooled and arranged in such a way that deficiency in the cooling supply will become at once evident to the operator.



EIGHT BATTERIES (3600 H.P.) DIESEL ENGINE PLANT

Each battery consists of two 225-HP Engines direct connected to 350-KW, A.C. Generators, the plant using fuel oil not heavier than 19 degrees Beaume scale and not containing more than one-half of one per cent of water.

Details of Construction

The exhaust valve, air admission valve and fuel valve all open in the cylinder head and are readily accessible, the latter two being contained in cages which, when removed, expose the exhaust valve and make it equally convenient to reach. These valves are operated from a cam shaft by push rods.

Lubrication of all parts within the crank case is taken care of by oil splashed over them by the rotation of the crank webs. A force feed oiler and a few cups complete the oiling system.

In the Diesel Engine the fuel consumption is absolutely covered from fuel in the storage tank to power on the engine shaft available for effective use.

There is no intermediate process, no boiler, producer, or even carburetors, upon which the operation and ultimate economy is dependent.

Igniters are not required, since the medium for compression and ignition is pure air; burning is gradual and continuous, with excess of air preventing premature combustion, explosion or failure to unite. No deposits of carbon or fouling of valves occur under these conditions; neither is there any objectional odor to the exhaust.

Fuel consumption is directly proportional to load and automatically regulated by a governor.

This sensitive governing device and the regular motion due to the gradual non-explosive pressures, fits the engine especially for work where smooth running is required, such as for parallelling alternators and the like.

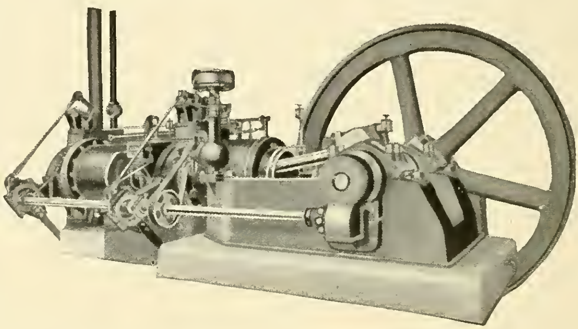
THE ST. MARYS MACHINE CO.

ST. MARYS, OHIO.

GAS ENGINES AND SUCTION GAS PRODUCERS; HEAVY-DUTY TANDEM GAS ENGINES; SINGLE-CYLINDER GAS, GASOLINE, SOLAR OIL AND DISTILLATE ENGINES; PORTABLE ENGINES; TRACTION ENGINES.

HEAVY-DUTY TANDEM GAS ENGINE

Maximum Size 480 h.p.

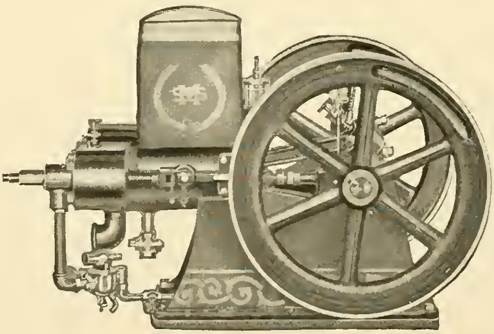


This engine operates on the four-stroke cycle. There are two cylinders arranged tandem, each having one single-acting piston. The two pistons are connected by a water-cooled piston rod, the front piston serving as a cross-head carrying the wrist pin, and but one connecting rod and crank is necessary as the pistons move together. This engine lends itself to various combinations for increasing the power of a plant.

DUPLEX SOLAR OIL ENGINES

50 h.p. up to 150 h.p.

This engine is designed for use with natural gas, city gas, gasoline, distillate, solar and crude oils, and is of the throttle-controlled type. An impulse is obtained at each revolution, resulting in greater steadiness.



The regulating device on these engines consists in vertical balanced valves which are moved by the governor and actuated by levers. The air and gas valve areas are proportioned to supply gas and air in the proper proportions to form an inflammable mixture of constant quality in any quantity that the governor may demand.

The lay shaft, igniter, eccentric, governor and pump are common to both cylinders. Each cylinder has its own regular mixing chamber attached directly to throttling chamber, doing away with long intake pipes that cause a governor to operate so sluggishly. This insures the correct amount of mixture in both cylinders, and at no time is the explosion greater in one cylinder than in the other or than the horse power required, hence a steady power.

SINGLE-CYLINDER SOLAR OIL ENGINES

10 h.p. up to 90 h.p.

These engines operate on the four-cycle plan and are designed to embody every feature calculated to insure the greatest strength and symmetrical appearance of the engine.

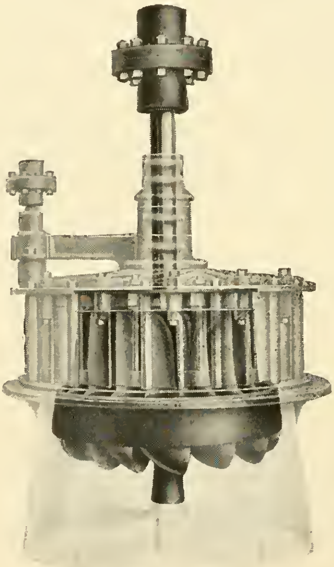
JAMES LEFFEL & CO.

501 LAGONDA ST.,

SPRINGFIELD, OHIO, U. S. A.

SAMSON AND NIAGARA HYDRAULIC TURBINES

SAMSON HYDRAULIC TURBINES



We build these turbines in all sizes and styles to meet the location and conditions. Our factory is equipped with the most modern machinery for turning out the very highest grade of turbine work and we have a most competent engineering force. Send us specifications and allow us to submit prices.

The tests recorded below were conducted by competent and disinterested engineers on one of our Special 35″ Samson turbines installed in the official testing flume at Holyoke.

Please note the very high efficiency and uniform speed at all gateages, and the great power.

Gate Opening	Head of Water in Feet	Revolutions of Turbine per Minute	Cubic Feet of Water per Second	HorsePower at Different Gate Openings	Efficiency at Different Gate Openings
Full Gate................	16.57	187	120.61	188.27	83.06
Nine-tenths Gate........	16.69	191	114.35	188.88	87.26
Eight-tenths Gate......	16.78	189	105.10	179.87	89.93
Three-quarters Gate....	16.86	187	100.29	172.57	89.99
Seven-tenths Gate......	17.08	188	92.83	160.03	88.99
Six-tenths Gate..........	17.23	185	77.15	128.22	85.05
Five-tenths Gate........	17.47	188	66.89	108.72	82.03

THE TERRY STEAM TURBINE CO.

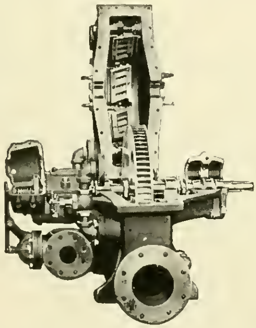
HOME OFFICE AND WORKS, HARTFORD, CONN.
GENERAL SALES OFFICE, 90 WEST ST., NEW YORK

MANUFACTURERS OF LOW SPEED STEAM TURBINES

TERRY LOW-SPEED STEAM TURBINE

for belted or direct connection has been specially designed to produce an efficient low-speed machine of very simple construction which would permit direct connection without attendant troubles, at the same time eliminating gears. Simplicity also means successful operation with but few parts, all easy to inspect.

The Terry Turbine is of the compound velocity stage impulse type, that is, the steam is practically wholly expanded in a correctly formed jet or nozzle, wherein its static pressure is converted into velocity energy.



Increased power for a wheel of given diameter is obtained by fitting additional jets into the casing, each jet having a supply of live steam which may be cut off when the load is light.

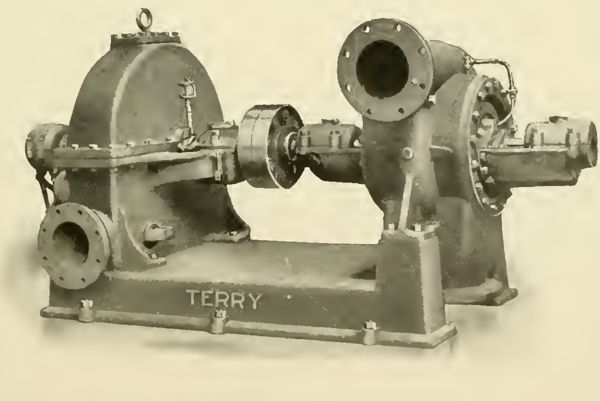
Each of the jets direct the escaping steam against the buckets on the rotor, after which the steam is successively reversed and directed against the rotor until it escapes at the exhaust.

As the flow of steam is at all times in a plane normal to the shaft, there is no end thrust regardless of initial pressure or vacuum.

Casing is subject to only a pressure corresponding to the exhaust pressure. Bracket bearings and short shaft make rigid construction.

SINGLE STAGE TURBINE-OPENED

The Terry Turbine is built condensing and non-condensing and either single or two stage. The smallest is rated for 5 H.P. and largest for 600 H.P. They have made a record of successful, economic operation for direct connection to dynamos, to forced draft fans and blowers, and to centrifugal pumps for boiler feed, hot well and circulating water service.



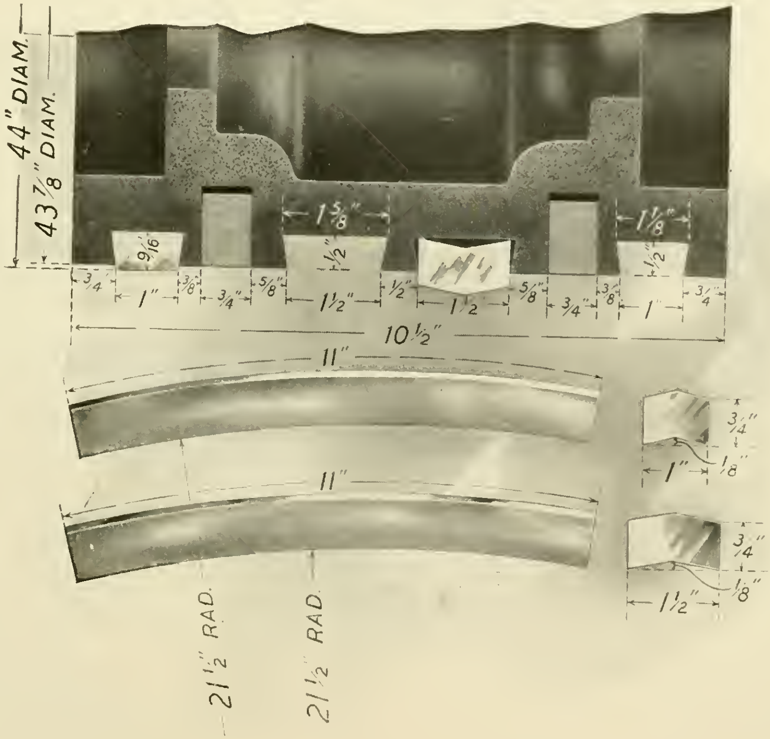
Non-condensing turbine driving 1900 g.p.m 8-in. pump.

ALLAN RED METAL

ALLAN RED METAL, our lead-copper alloy, a metal of excellent wearing and anti-friction qualities, made by the Allan Process, the only process whereby lead and copper can be mixed into a homogeneous alloy.

Tin, owing to its adhesive qualities, is a very undesirable metal in anti-friction alloys for service where high-speed and a high degree of heat are to be met. Allan Red Metal contains no tin and will not, under the most trying conditions, hug, stick or sear the pin or rod. Owing to its high fusing point, this metal is unmeltable by friction.

The uninterrupted growth in the output of Allan Red Metal during the past twenty years we feel is sufficient evidence of its worth for facing high and low-pressure pistons, piston rod and valve stem packings, mill, motor, dynamo and engine bearings and as globe valve discs.

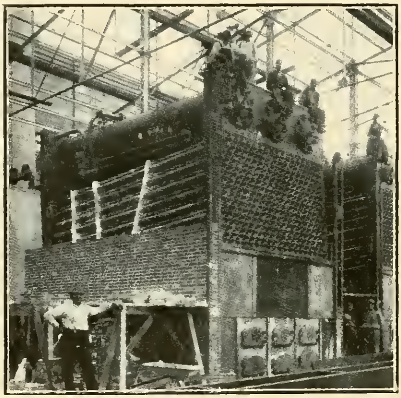


The illustration shows how pistons are constructed for Allan Red Metal. Dove-tailed grooves are cut around piston or bull ring and should be one-half inch deep. Width of grooves at face of piston from one to two inches. The rings are furnished cast in segments and are peened or hammered down until the metal is forced into the grooves and locked by the splay. Our booklet, "The Heart of the Engine—the Seat of Power," covers in detail the application of Allan Red Metal to pistons.

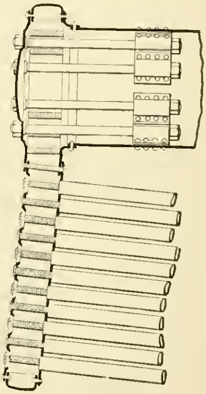
EDGE MOOR IRON COMPANY

EDGE MOOR, DELAWARE

Manufacturers of Water Tube Boilers, in four sections, consisting of front and back headers, drums and tubes. The construction of headers and their connection to drums is designed to avoid contraction of circulation at those parts. Surfaces and storage capacity is large and the boiler responds quickly to unusual demands and maintains a steady water line.



Typical Setting



Front Header

Passing of gases may be arranged in several ways and any type of stoker or grate may be used. A sliding hearth plate facilitates cleaning fires. Superheaters may be connected in several ways and are designed to require little attention and no flooding. They add nothing to the width of setting We are prepared to build boilers from 6 tubes wide up to 30 tubes wide and 6 to 16 tubes high, from 1 drum up to 5 drums and tubes 18′ to 20′ long. Typical Setting with 18-foot tubes has length over all of 20′10½″ Length of Furnace may vary in length from 60″ to 144″. Width of Furnace may vary per column A of table below. Height of Setting varies from 11′–10″ up to 20′–9″ overall. To determine width of setting for given H. P. add to dimension from Col. A–17″ each for side walls and 22″ for partition in double setting. Add 6″ each side for buckstays. Tubes draw front or rear.

TABLE GIVING RANGE OF NOMINAL H.P.
For Different Widths of Setting

A	Horse Power	A	Horse Power
4′ 5″	100 to 210	12′ 1″	270 to 600
5′ 0½	115 " 240	12′ 9″	285 " 630
5′ 8″	125 " 270	13′ 4½″	300 " 660
6′ 4″	140 " 300	14′ 0″	315 " 700
6′ 11½″	155 " 340	14′ 8″	335 " 730
7′ 7½″	170 " 375	15′ 3½″	350 " 760
8′ 3″	180 " 405	15′ 11½″	360 " 790
8′ 10½″	200 " 435	16′ 7″	375 " 820
9′ 6½″	215 " 465	17′ 2½″	395 " 850
10′ 2″	230 " 505	17′ 10½″	410 " 880
10′ 9½″	245 " 535	18′ 6″	425 " 915
11′ 5½″	260 " 565	19′ 2″	435 " 945

THE WICKES BOILER COMPANY

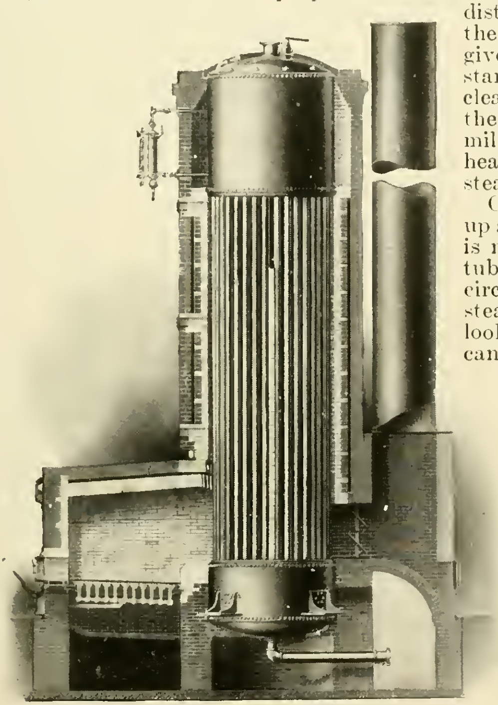
SAGINAW, MICHIGAN, U. S. A.

VERTICAL WATER TUBE BOILERS; RETURN TUBULAR BOILERS; FEED WATER HEATERS AND PURIFIERS.

VERTICAL WATER-TUBE BOILERS

These boilers are designed for high efficiency and dry steam. The illustration gives a clear idea of the construction, which consists primarily of upper and lower drums and the boiler tubes connecting them.

The steam drum is arranged to give a height of sixty-six inches from the water line to the crown sheet, from which the steam outlet is taken. This high drum serves several purposes. It furnishes dry steam, owing to the distance from the surface of the water to the outlet; it gives room for workmen to stand inside the drum when cleaning the tubes, and since the shell is subject to a mild degree of heat some superheating is effected upon the steam.



Circulation of the water is up and down and the tube area is made equal in both sets of tubes in order to provide free circulation both for water and steam. Every tube can be looked into. Steam pockets cannot form, and the arrangement equalizes heating throughout the boiler.

The furnace is of the external oven type, the grate surface being entirely surrounded by highly heated surfaces in order to avoid chilling the products of combustion.

Any type of stoker may be applied to the furnace.

Hot gases flow from bottom to top and then down to the bottom, the boiler being divided into two halves by a tile partition which is readily renewable.

Blow off is located at the very lowest point of the bottom mud drum. Feed water is usually introduced into the steam drum, directly into the down-take tubes far below the water line.

EXHAUST STEAM OPEN HEATER AND PURIFIER

Our Heater and Purifier for feed water contains a series of basins for heating the water and for precipitating its impurities. At the bottom is a water chamber for receiving the water which has been heated in the basins. This water chamber contains a float valve which maintains the level of the water in the chamber by admitting feed water into the upper basin, from which it makes its way down to the bottom, being heated by exhaust steam as it falls. An improved oil separator is fitted upon this heater.

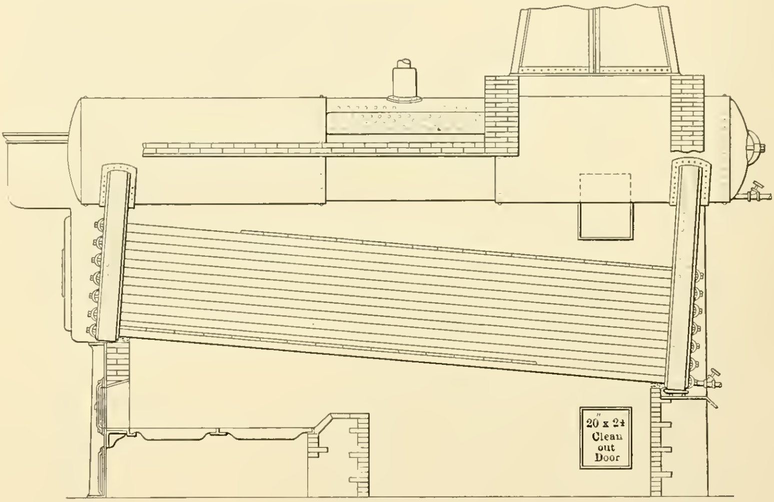
JOHN O'BRIEN BOILER WORKS CO.

ST. LOUIS, MISSOURI

BOILERS OF THE WATER TUBE, HORIZONTAL, TUBULAR, INTERNALLY FIRED, AND VERTICAL TYPES.

WATER TUBE BOILER—TYPE "A"—With Horizontal Baffle

The tubes are inclined on a pitch of from one to three inches to the foot. The rear water leg being longer, the overhead drum connecting both legs lies perfectly level when the boiler is set in position.



On a test for efficiency made at the St. Louis Water Works, we obtained a bonus of $12,000 over the contract price for the high economy secured on the above type of boiler.

The following is a copy of the report of official boiler test—John O'Brien 300-horse power Water Tube Boilers with down-draft furnaces.

BOILER TEST

ON BOILER NO. 4—HIGH SERVICE STATION NO. 3—BADEN

Date of test January 28-29, 1898 — Duration of test from 8:30 a.m. to 8:30 a.m.

DIMENSIONS AND PROPORTIONS

	Upper	Lower
(1) Grate surface, sq. ft......	37.6	50.3
(2) Total water heating surface, sq. ft..................	2771	
(3) Superheating surface, sq. ft..................		
(4) Ratio water heating surface to upper grate surface....................	73.7	

Pressures

(5) Steam pressure by gage in boiler, lb	126.8
(6) Absolute steam pressure in boiler, lb	141.3
(7) Barometer, in	29.60
(8) Draft gage, in. of water	0.61

Temperatures

(9) External air, deg. fahr	38.2
(10) Boiler room, deg. fahr	63.4
(11) Steam, deg. fahr	353.8
(12) Flue, deg. fahr	468.0
(13) Feed water, deg. fahr	101.0

Fuel

(14) Total coal consumed, lb. ½ Mt. Olive, ½ Carterville	29541
(15) Coal per hour, lb	1231
(16) Ash removed, lb 8.86%.	2618
(17) Total combustible, lb	26923
(18) Combustible per hour, lb	1122
(19) Coal burned per sq. ft. grate surface per hour lb. upper	22.8
(20) Coal burned per sq. ft. heating surface per hour, lb	0.444
(21) Coal burned per sq. ft. least draft area per hour, lb	97.7
(22) Calorific value of coal (per Thompson calorimeter), B.t.u	11535

Calorimeter Test

(23) Quality of steam (per Barrus calorimeter), percent	99.53
(24) Moisture in steam, per cent	0.47
(25) Superheat, deg	
(26) Total moisture in steam, lb	1019

Water

(27) Total water evaporated, lb	216854
(28) Total water evaporated, corrected for moisture, lb	215835
(29) Factor of evaporation	1.1606
(30) Evaporation from and at 212 deg., lb	250498
(31) Evaporation per lb. of coal, actual, lb	7.31
(32) Evaporation per lb. of coal, from and at 212 deg., lb	8.48
(33) Evaporation per lb. of combustible, actual, lb	8.02
(34) Evaporation per lb. of combustible, from and at 212 deg., lb	9.31
(35) Evaporation per sq. ft. H.S. per hour, actual, lb	3.25
(36) Evaporation per sq. ft. H.S. per hour, from and at 212 deg., lb	3.77
(37) Evaporation per sq. ft. G. S. per hour, actual, lb., upper	239
(38) Evaporation per sq. ft. G. S. per hour, from and at 212 deg., lb. upper	277

Horsepower

(39) On a basis of 30 lb. of water evaporated per hour, from temperature 100 deg. fahr., into steam of 70 lb. pressure (34.5 lb. from and at 212 deg.)	302.5
(40) Builder's rating	300
(41) Per cent above rating	0.83
(42) Sq. ft. H. S. per Hp	9.19

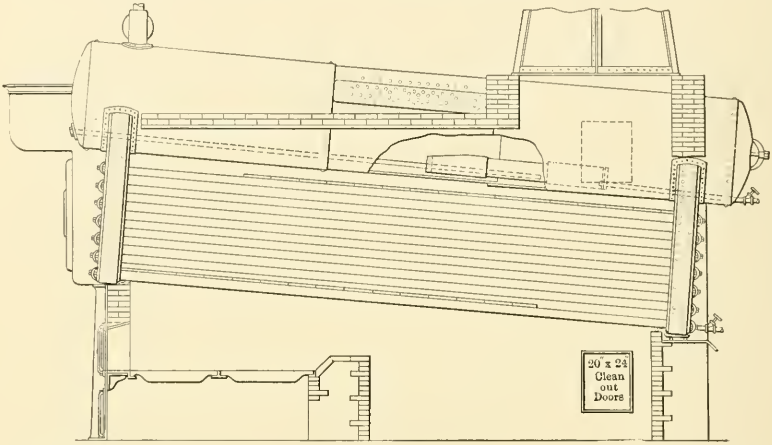
Efficiency

(43) Heat generated, B.t.u	340755000
(44) Heat absorbed, B.t.u	241906000
(45) Efficiency of boiler, per cent	71.0

JOHN O'BRIEN BOILER WORKS

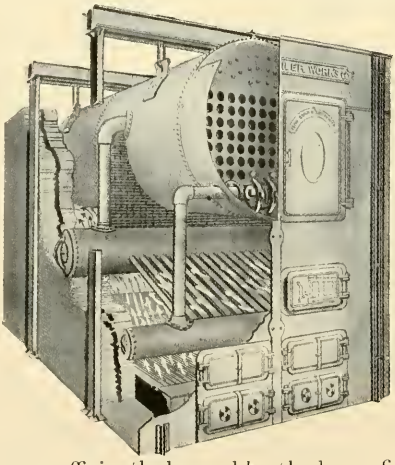
WATER TUBE BOILER—TYPE "B"—With inclined drum

The drums of this boiler are set parallel with the tubes and when in position show an incline of one inch to the foot.



To meet all demands we build all our boilers with either the vertical or the horizontal baffle and when desired can cover the bottom row of tubes on the horizontal pass of gases with box tile which gives the dutch oven effect and insures, when properly fired, practically a smokeless furnace. Flues either 3½ in. or 4 in. in diameter are furnished.

THE O'BRIEN-HAWLEY IMPROVED SMOKELESS DOWN-DRAFT FURNACE



This furnace is constructed with two separate grates, one above the other. The upper grate is formed of a series of tubes opening at their ends into drums or manifolds through which the water of the boiler continually and rapidly circulates. The tubes form the fire grate. Air for combustion enters through fire doors near the top of the furnace.

The division wall at the back of the furnace deflects the draft down through the fire upon the upper grate and over the fire on the lower grate. The fire on the lower grate is entirely fed by coked coal falling from the upper grate and the unconsumed gases and smoke from the upper fire are efficiently burned by the lower fire.

The lower grates are of common bars accessible through flue doors for cleaning and spreading.

A few comparative tests with other furnaces made by Prof. Wm. B. Potter, Capt. Wm. McClellan and Wm. H. Bryan, members of the St. Louis Smoke Commission, showed that when compared on the basis of percentage of calorific power utilized the O'Brien-Hawley furnace gave results of 68.53, 78.66, 73.69, 68.94 and 80.6% against 64.8, 72, 56.6, 57.03, 57.5, 56.64 and 46.93% for other types of furnaces.

GREEN ENGINEERING CO.

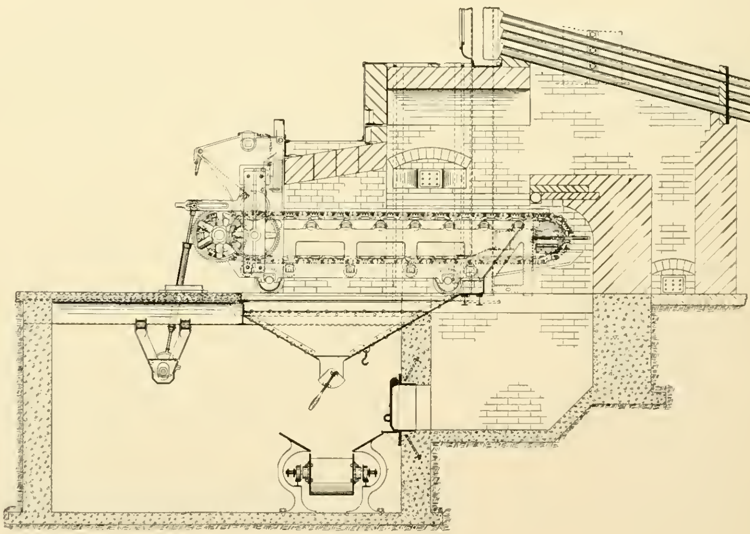
CHICAGO ILLINOIS

MANUFACTURERS OF GREEN CHAIN GRATE STOKERS; GECO RATCHET ASH DRAGS; GECO PRESSURE WATERBACKS; GECO PNEUMATIC ASH HANDLING SYSTEMS.

GREEN CHAIN GRATE STOKER

The Green Chain Grate Stoker gives in service a practical demonstration of progressive combustion, the fuel being fed in at the front of the furnace and carried at regulated speed to the rear of the furnace, where, as ashes, it drops into the ash pit to be removed mechanically or by hand. Operation is entirely automatic and continuous. The fuel is ignited and coked at the front end of furnace, air is admitted through automatically cleaned air spaces in grate, and smokeless combustion with low grade fuel is produced. It will quickly pick up or drop a heavy load or economically bank the fire. Labor cost for cleaning furnace is low and the cost for repairs minimized.

Green Stoker Applied to a Horizontal Boiler

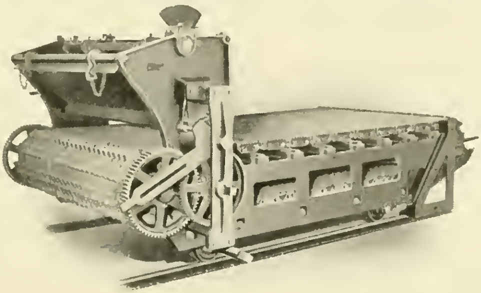


Construction

Two types of grates are made adaptable to any make of boiler. The fire bed may be level or sloping. The side girders of frame are entirely removed from the furnace away from the fire and arranged to provide an increased air supply. Heavy cast-iron links, thoroughly ventilated, form the firing bed. These links interlock and automatically clear the air spaces without excessive loss of fine coal. The rear cross girder is fitted with a heavy plate on under side upon which ashes accumulate and, in connection with the members just above and below, prevent the passage of air around rear portion of grate, where ashes discharge; and this is further supplemented by dampers.

GREEN CHAIN GRATE STOKER

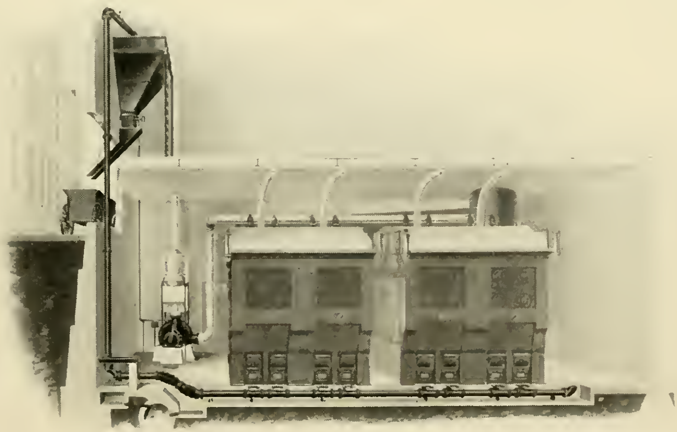
The grates are built in any width and in lengths from 9 ft. up to 12 ft. deep. Driving mechanism consists of ratchet, cast steel-pawls and cast-steel spur gear train babbitted in a special self-contained frame independent of, but bolted to the stoker front side frame. Quick adjustment may be had over a wide range and the source of power may be either above or below the boiler-room floor. A regulating feed-gate permits hard firing and is provided with an easily renewable tile lining, which prevents injury to the gate by fire eating back into coal hopper. The igniting arch is adaptable to any width furnace and easily renewable at low cost. Its construction is flat, ventilated, and gives uniform ignition full width of furnace and allows local repairs at any point without undue loss of use of the boiler.



Stoker Withdrawn From Setting

GECO PNEUMATIC ASH HANDLING SYSTEM

This system consists of a conveyor pipe located convenient to ash pits and provided with openings into which ashes are readily hoed. An air current of high velocity instantly carries the ashes to a separator and storage tank. On entering tank the ashes are automatically sprayed, thoroughly quenched, separated from air and deposited. An exhauster produces the air current. Tank may be readily emptied by gravity into carts, or cars. One man operates system.



THE GREEN FUEL ECONOMIZER CO.

MATTEAWAN, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal

FUEL ECONOMIZERS for recovering waste heat from boiler furnaces, kilns, metallurgical furnaces, core ovens, gas engines, etc., to heat water for boiler feeding and other purposes.

WASTE HEAT AIR HEATERS, similar to the economizer and utilizing heat from the same sources for heating air, for the heating of buildings or drying purposes or for regenerative furnaces.

FANS, BLOWERS, EXHAUSTERS, for moving air for all purposes.

ENGINES, horizontal and vertical, slide-valve or automatic, for driving fans.

POSITIVFLO HOT BLAST HEATERS for live or exhaust steam or hot water.

DRYING EQUIPMENTS for all kinds of material.

HEATING AND VENTILATING EQUIPMENTS.

MECHANICAL DRAFT INSTALLATIONS.

THE GREEN FUEL ECONOMIZER.

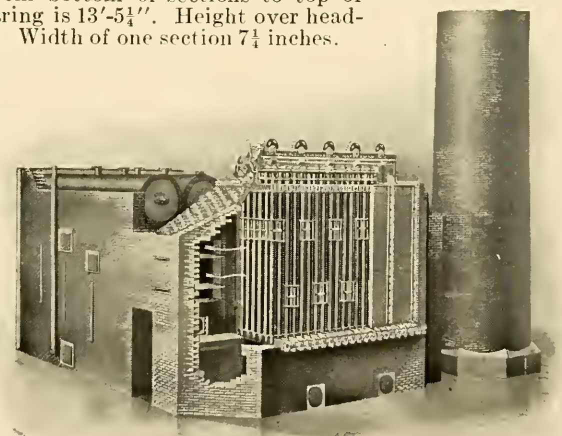
The Green Economizer has been perfected by sixty years use. The standard economizer consists of vertical cast-iron tubes about nine feet long, made up in sets or sections of various numbers of tubes to fill out any width. These groups of tubes are pressed into top and bottom headers. The sections thus formed are assembled to make any length desired and are connected with top and bottom branch pipes running lengthwise, one at the lower corner and the other at the diagonally opposite upper corner.

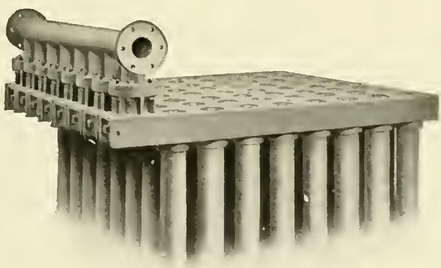
The waste gases of combustion are passed among these tubes on the way to the chimney and the heat in the gases is transferred to the water in the tubes.

The water is fed through the economizer by a force pump or injector flowing in general in a direction counter to that of the gases.

In the illustration below is shown a conventional method of installation.

Height from bottom of sections to top of scraper gearing is 13′-5¼″. Height over headers 10′-2½″. Width of one section 7¼ inches.





Group of Green Fuel Economizer Sections, Showing the New Extended Top Header with Branch Pipe

The tubes are of a special grade of iron cast in vertical dry sand molds and tested to 500 lb. pressure per square inch before forming into sections; 350 lb. after forming and twice the working pressure when installed.

The junction between the tubes and top and bottom headers is a metal-to-metal joint formed by pressing all the tubes of a section into both headers at one operation. To accomplish this the tubes have accurately turned tapered ends fitting into corresponding sockets in the headers.

The connections between the top and bottom headers and the branch pipes are entirely outside the economizer chamber and are easily made and unmade by the ordinary mechanic. They have sufficient flexibility to take care of unequal expansion due to changes of temperature and distortion due to slight unequal settlement of foundations.

Our latest type of Top Header is made extended as shown in the illustration above. To this extension is attached the branch pipe as shown in the illustration. Out latest type Ovoid Bottom Header is specially designed to permit the soot to fall through as it is removed by the scrapers.

Three scrapers encircle each pipe, with joints overlapping. These scrapers rest on a lifting bar and are kept in place by a guard. They are caused to travel constantly up and down by a simple form of automatically reversing gear.

Access to every part of the exterior and interior of the economizer is complete and easily accomplished. The economizer as a whole is arranged to secure the greatest heat absorption with the least impediment to the draft.

THE GREEN WASTE HEAT AIR HEATER

is similar in construction and application to the economizer, with the difference that air is passed through the tubes instead of water. The air is passed down through one set of tubes and then up through another. This apparatus is used for industrial drying or heating or as a heat regenerator in gas works, etc.

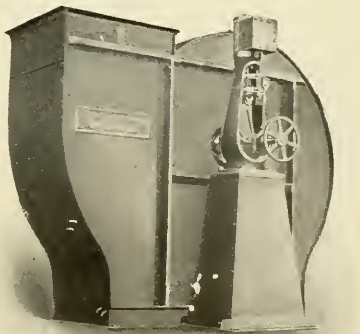
GREEN STEEL PLATE FANS

are constructed for every purpose and in sizes to suit every requirement.

We have improved the construction of our fans and wish to emphasize their substantial and smooth running qualities.

Wheels and housings are extra heavy and bearings are ring-oiled and adjustable.

The wheels are adjusted to running balance and are strengthened by angle iron rings on the larger sizes; angle iron fastenings for the floats.



Send for special treatises on (1) Fuel Economizers, (2) Fans and Blowers, (3) Heating and Ventilation, (4) Mechanical Draft, (5) Drying, (6) Waste Heat Air Heaters, (7) Planing Mill Exhausters, (8) Heat Saving in Water Gas Plants.

LACLEDE-CHRISTY CLAY PRODUCTS CO.

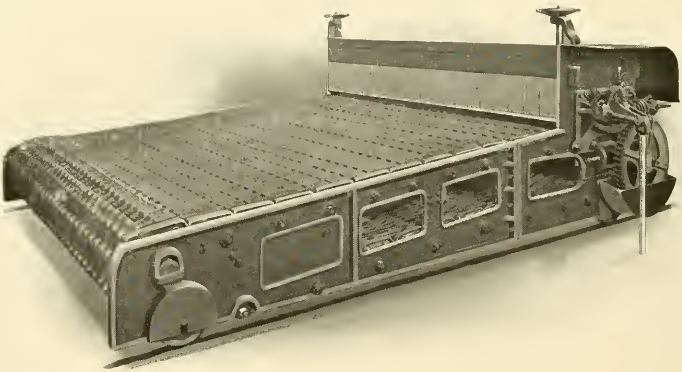
ST. LOUIS, MISSOURI

"LACLEDE-CHRISTY" CHAIN GRATE STOKERS; CLAY PRODUCTS AND REFRACTORIES; INDUSTRIAL PLANT CONSTRUCTION.

CHAIN GRATE STOKER

The "Laclede-Christy" Chain Grate consists of an automatic, traveling, self-cleaning endless chain of narrow links all of the same design, supported on a strong rigid frame and operated by a simple driving device.

By means of a hopper and an adjustable feed gate, the coal is spread evenly across the width of the grate and carried under the patent ignition arch where the volatile gases are driven off and consumed. The remaining coke is consumed toward the back of the grate and the ashes discharged into the ash pit at the rear end of grate.



The frame work which supports the chain consists of heavy cast-iron sides tied together with rods and pipe spreaders and held rigid by a structural iron diagonal brace. Pipe rollers are provided to support the chain and the complete grate is mounted on four flanged wheels to fit tee rails. By this construction the stoker can be removed quickly from under the boiler for repairing the furnace.

Driving mechanism consists of a worm gear operated by a pawl and a ratchet wheel, driven by an eccentric fastened to a shaft either overhead or underneath. Speed may be closely regulated and in case of accident to the engine or motor the grate may be operated by hand.

SPECIAL FEATURES

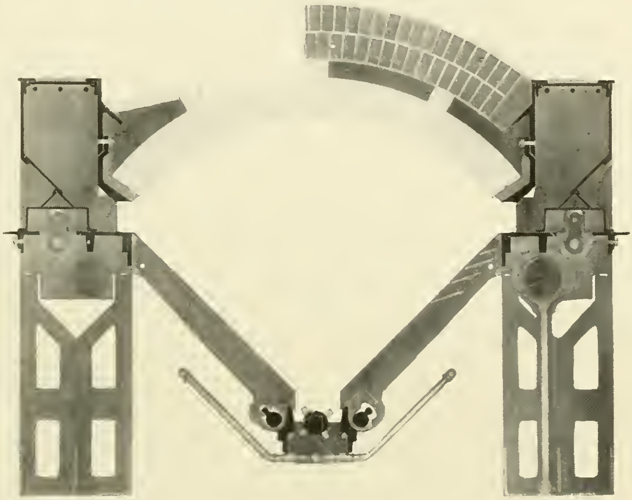
Evaporation is produced at a minimum cost for fuel and labor.
Boiler can be forced without losing economy.
It will burn any kind of coal without smoke.
It is self-feeding, self-cleaning and labor saving.
Combustion chamber is large, promoting combustion, preventing smoke.
During operation it may be quickly adjusted.
Sprockets engage rollers instead of links.
It does not injure boilers or accessories.
Any fireman can make repairs should they become necessary.

THE MODEL STOKER COMPANY

DAYTON, OHIO

THE MODEL AUTOMATIC SMOKELESS FURNACE. A STOKER FURNACE FOR POWER BOILERS WHICH BOTH STOKES AND CLEANS THE FIRE AUTOMATICALLY, INSURES PRACTICALLY COMPLETE OR SMOKELESS COMBUSTION AND GIVES DECIDED FUEL ECONOMY.

CONSTRUCTION AND OPERATION



The illustration shows the internal construction, arrangement of grate surface, fire arch, air flues, coal magazines and a section of the system of steam shower pipes which are a vital part of the means by which this furnace keeps the fire clean.

The grates, are arranged in pairs inclined from the sides to the centre bearer; one of each pair is stationary and the other is moved by the rocker bar up and down. This movement of the alternate bars produces a shearing motion which prevents the coal and clinkers from sticking while the weight of the fresh coal above and the positive push of the stoker boxes move the coal slowly and steadily down the incline and preserves uniformity of fuel bed over entire grate surface. The narrow surface each grate presents to the fire and the great depth of the bar and consequent surface for contact of air insure durability.

OPERATING MECHANISM

The mechanism is efficiently protected from undue heat and all bearings and operating gear are outside of the furnace, protected from heat and readily accessible.

The driving engine is placed at the side of the furnace, and by a double set of worm gears and connections, communicates the necessary motion to the stoking and cleaning mechanisms. One engine will operate several stokers if desired. It is also possible to detach the levers which operate the stoker shafts or other parts and operate any part by hand without stopping engine. The clinker crusher at lowest point of grates has arrangements for disconnecting and for changing speed, to suit amount of refuse, and keeps the fire clean.

MURPHY IRON WORKS

DETROIT, MICHIGAN

FOUNDED 1878

MANUFACTURERS OF THE MURPHY AUTOMATIC SMOKELESS FURNACE

THE MURPHY AUTOMATIC FURNACE is automatic in all its functions. It feeds and distributes the coal and removes the ash and refuse.

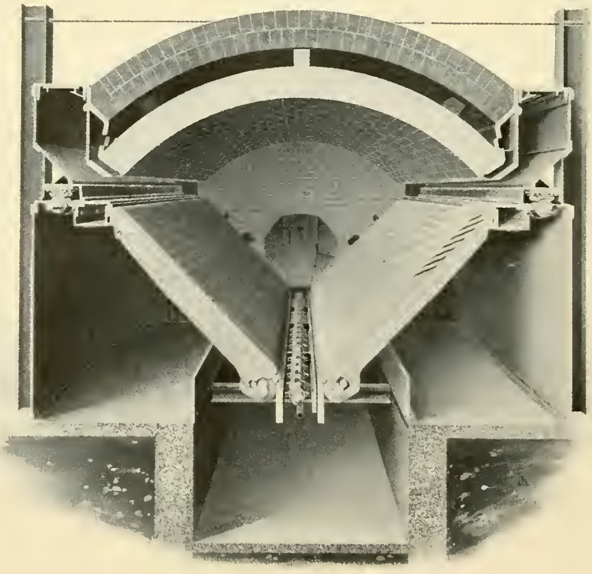
It is adaptable to any type of boiler and to units of any size.

It will handle economically all grades of bituminous fuels and is practically smokeless under normal operating conditions.

It is capable of handling variable loads and heavy overloads efficiently and with minimum attention.

The cost of maintenance is low, averaging about 10c. per horsepower per year.

It operates with natural draft, the cost of actuation approximates ¾ of 1 per cent of total steam generated.



The Murphy Automatic Smokeless Furnace
REAR VIEW

Its usefulness is not limited to steam making, it will give excellent results in all operations where high temperatures are required, such as brick drying, cement burning, salt evaporation, calcining of soda ash, heating furnaces, etc.

MURPHY IRON WORKS

Murphy Furnace—Dutch Oven Setting

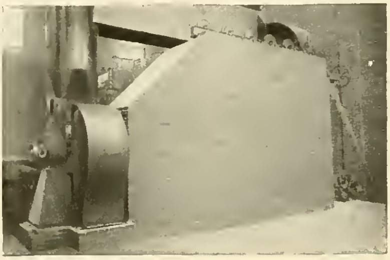
At either side of the furnace extending from front to rear is the coal magazine into which the coal may be introduced either by hand or mechanically. At the bottom of this magazine is the coking plate against which the inclined grates rest at their upper ends. The stoker boxes, operated by segment gear shafts and racks, push the coal over the coking plate and onto the grates. The grates are made in pairs, one fixed and the other movable. The stationary grates ,at their lower ends, rest on the grate bearer, which also acts as a support for the clinker grinder. The clinker grinder consists of a square steel shaft, onto which is slipped small cast iron toothed segments, which are readily replaced in case of breakage. Just over the coking plate is the arch plate, from which a fire brick arch is sprung over the entire furnace. Upon this arch plate are cast numerous ribs to form a series of air ducts immediately over the coking plate, conveying the heated air from the chamber above the arch into the combustion chamber. This arch plate also forms the wall of the magazine. The furnace, or battery of furnaces, can be operated by a small automatic engine, motor or by overhead shaft and ratchet drive, as may be desired. Arrangement is made for exhaust steam connections at the lower end of the grates for the protection of this portion of the grates and clinker grinders and for the softening of the clinker. In connection with horizontal tubular boilers or water tube boilers horizontally baffled, the Murphy furnace can be installed with a flush front setting. Arrangement can be made for extended or Dutch oven settings, should this be desired.

B. F. STURTEVANT COMPANY

HYDE PARK, MASS.

MECHANICAL DRAFT; FUEL ECONOMIZERS; VENTILATION; HIGH PRESSURE BLOWERS; ENGINES AND GENERATING SETS; PNEUMATIC CONVEYING AND SEPARATING; STEAM TURBINES; STEAM TRAPS; EXHAUST HEADS.

MECHANICAL DRAFT



Mechanical draft will do what an ordinary chimney cannot effect. Its cost is sixty to eighty per cent less than a chimney; its intensity of draft permits the burning of finely divided or low grade fuel; flue gases may be utilized which a chimney wastes in producing draft; it is independent of the weather; decreases smoke; saves space and is portable.

Either forced draft or induced draft system may be used, forced draft being particularly applicable to old plants in which additional boiler capacity is required. In forced draft the air is discharged into the ash pit through openings in the sides or bottom.

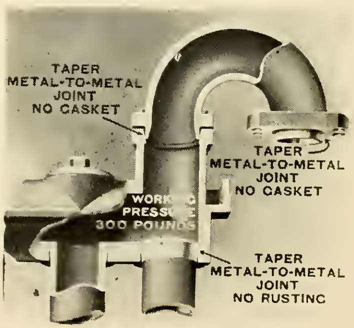
Induced draft is so arranged that the gases are drawn through the fan, and a partial vacuum is maintained in the boiler furnace. The fan is usually installed overhead, where it occupies no valuable floor space and dicharges through a short stack extending just above the roof. The shaft runs in water-cooled journal boxes so that hot gases may be handled with impunity.

Under either system the fan is usually equipped with a direct-connected engine automatically regulated to maintain constant steam pressure, and arranged to operate fan when remainder of plant is idle.

FUEL ECONOMIZERS

To utilize waste heat in flue gases is the duty of an economizer, which is placed in the path of the gases and absorbs a large proportion of the heat, raising the temperature of the feed water.

Either mechanical draft or an economizer may be installed independently or together. Maximum saving results when both are used. When the combination of economizer and mechanical draft is used, the flue gases can be reduced to a very low temperature, thus getting the most out of the escaping heat, as the mechanical draft requires no heated gases to give perfect draft.

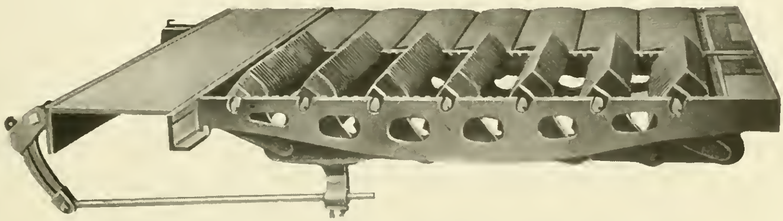


An economizer saves fuel, acts as equalizer of variable load in power plants, acts as an equivalent to extended heating surface on a boiler, increases boiler capacity, adds to the life of boilers, purifies feed water, reduces repairs and deposits soot in large quantities. In the Sturtevant Economizer the pipes are arranged "staggered" instead of in straight rows. The number of joints is minimized and they are made taper, metal-to-metal. The headers are machined and finished to a gauge. An interchangeable, bevel-edged scraper moves continously up and down each pipe, positively scraping the soot from the surface.

CYCLONE GRATE-BAR CO.

BUFFALO, N. Y.

THE CYCLONE PATENT SHAKING AND DUMPING GRATE



Cyclone Shaking and Dumping Grates for any size Furnace

Admits 68% of the available air.

Cannot waste fuel when shaken.

Openings no greater when shaken than when locked level.

When ars are thrown into dumping position residue of fire clears working parts.

Bars lock level and cannot get out of adjustment.

Damage by accident or careless handling fully guarded against.

Will burn any kind of fuel.

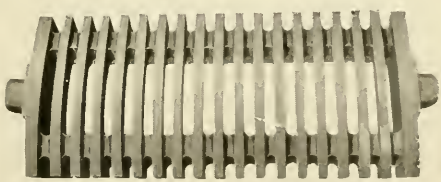
Special bars for every kind of fuel.

Bars are braced and trussed to prevent warping.

There are no points or fingers to burn off.

The filing movement when shaken cuts the ash withoxt disturbing the fire.

Sections of Bars



The Face of the Bar

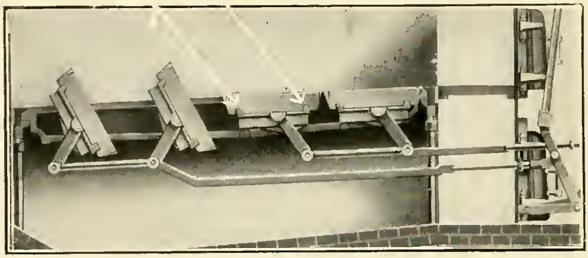
WASHBURN & GRANGER

50 CHURCH STREET, NEW YORK

THE DEAN DUMPING GRATE; DEAN SHAKING GRATE; COMBINATION SHAKING AND DUMPING GRATES OR STATIONARY GRATES.

THE DEAN DUMPING GRATE

The illustration shows a twelve-cradle grate for a furnace 10′ 4″ wide by 7′ 0″ deep. The rear grates are tipped for dumping. To clean the front half of the grate the live coals are first moved to the rear bars. Tipping cradles to angle of 65 degrees frees the grate instantly of ash and clinker. The bars are then returned to normal position and all the live coals pulled forward to permit the rear grates to be dumped and cleaned, after which the fire is spread and covered.

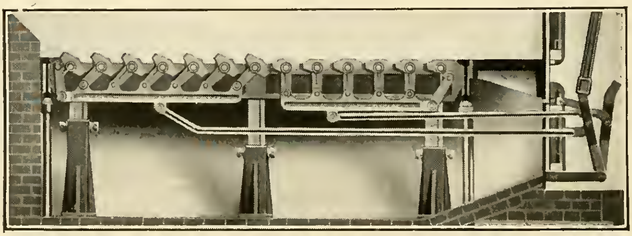


This type of grate is particularly adapted to deep furnaces and fireboxes of water-tube boilers in which the bridge walls are built up to the tubes.

The grates rest in cradles, are free to expand and contract and are readily removable. The cradles offer a two-point bearing for the bar which prevents them from warping as occurs in bars supported only at the middle. The cradles are dumped in tandem by levers operated at the front of the boiler.

THE DEAN SHAKING GRATE

The illustration below shows a six-section shaking grate, built three sections wide for bituminous coal. This view shows adjustable legs by which the grate may be raised or lowered at the bridge wall or adjusted



at any time to accommodate an increased thickness of fire. This is impossible where grates are built into the brick work. The type shown also has the advantage of freedom for expansion and contraction.

The entire grate surface moves when operated, even to the end bars. This enables the fire to be cleaned from bridge wall to dead plate solely by the movement of the grates.

COMBINATION SHAKING AND DUMPING GRATES OR STATIONARY GRATES

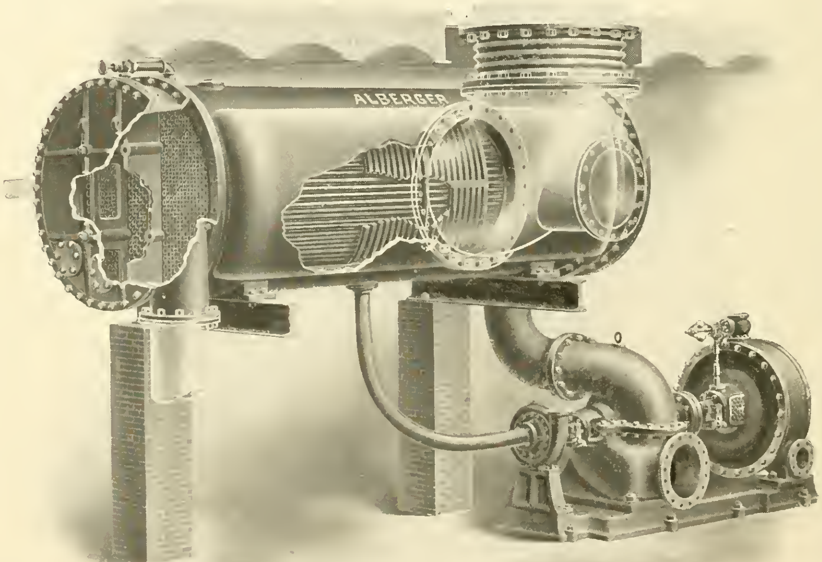
We manufacture grates for all sizes of furnace and in any combination for all grades and sizes of coal. Standard grate bars, boiler fronts and firing tools furnished promptly.

ALBERGER CONDENSER COMPANY

140 CEDAR STREET, NEW YORK, N. Y.

HIGH VACUUM SYSTEMS FOR STEAM TURBINES; SURFACE, BAROMETRIC AND CENTRIFUGAL CONDENSERS; VACUUM PUMPS; CENTRIFUGAL PUMPS, VOLUTE AND TURBINE TYPES FOR ENGINE, MOTOR, BELT OR STEAM TURBINE DRIVE; WAINWRIGHT HEATERS AND EXPANSION JOINTS.

ALBERGER COUNTER CURRENT SURFACE CONDENSER

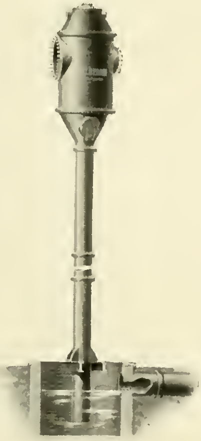


In the Alberger counter-current surface condenser the steam enters at the bottom, the air and uncondensable vapors are taken out at the top by means of a dry vacuum pump, the circulating water enters at the top, and passes through the tubes in a downward direction, coming out at the bottom. The water of condensation passes through the entering steam and is removed from the bottom of the condenser by means of a condensation pump.

One form of this condenser is illustrated in the cut above. In this case the steam enters at the side, the air is taken out from the side opposite the entering steam, the circulating water flows horizontally in a counter direction to the steam.

ALBERGER CONDENSER COMPANY—Continued

ALBERGER BAROMETRIC CONDENSER



This condenser is of the elevated jet type, the condenser cone being supported above a tail pipe approximately 34 ft. long, which removes the condensing water and water of condensation by means of gravity. A dry vacuum pump is used for removing the air and uncondensable vapors from the system. This arrangement reduces to a minimum the quantity of water required for condensing purposes. An automatically adjusted spray distributes condensing water in the cone, giving the most efficient condensing surface possible, bringing the steam and the water into contact intimately.

ALBERGER CENTRIFUGAL CONDENSER

This condenser is a modification of the barometric type, the tail pipe being replaced by means of a centrifugal removal pump, which takes the water from the condensing cone and discharges it into the atmosphere. The injection water is drawn into the condenser by means of the vacuum. This type of condenser permits of its being placed within the engine room and usually a short steam connection can be made to the prime mover. The dry vacuum pump is used for removing the air and uncondensable vapors from the system in order to reduce to a minimum the quantity of condensing water.

ALBERGER COOLING TOWERS

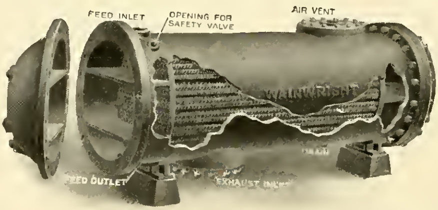
In cases where there is insufficient supply of water for condensing purposes, the Alberger cooling towers are used. These towers artificially cool the water so that it can be continuously re-used in the condenser for condensing purposes, it being only necessary to supply a small quantity of water to make up the losses due to evaporation. These towers can be installed in cities, being placed upon roof structures when ground is not available. They are built in three types:—

The first consists of a steel tower constructed over a tank for receiving the cooled water and filled with a special swamp cypress filling, which acts as a distributing medium for the water to be cooled. Fans are placed on a horizontal shaft at the base of the tower, forcing air through the filling and producing the cooling effect. They may be driven by motors, engines or steam turbines, usually with belt drive.

The second type is the Alberger natural-draft tower, in which no fans are used, the casing being extended to a height of approximately 70 ft., the air being drawn through the filling by means of a natural draft.

The third type is the Alberger convertible cooling tower, which combines and improves upon all the good features of the fan-type tower, and the natural-draft tower, permitting of the operation of the tower under forced draft when weather conditions are severe, and under natural draft when weather conditions are favorable, with a resultant economy in operation. In this type of tower the stack is extended to an approximate height of 70 ft., to permit of natural draft operation. A vertical shaft is placed above the filling in the base of the upper portion of the stack, and when the fan is needed it is driven by means of a hydraulic pump placed in the engine room, supplying water under pressure to a water wheel attached to the fan shaft. When operating under a natural draft the hydraulic pump is shut down and the fan then automatically drops out of position, permitting a free natural draft.

WAINWRIGHT EVEN-FLOW HEATER



The Wainwright Heater is of the water tube type and is designed and constructed so as best to accomplish the transmission of heat from steam to water, and to fulfill the practical operating requirements of the power plant. The design is such as to utilize to the greatest extent possible the fact that heat transmission through the walls of tubes is greatly increased by agitation of the water across the heating surface. Full advantage is taken of the benefits to be derived from the use of counter currents in the flow of the steam and water. Cast iron and pure copper only are used in the construction of this heater. Inasmuch as these materials are not affected by the characteristic influences to be found in heating water, it follows that a long and even life of the heater is assured.

The heating surface consists of straight tubes of pure copper, corrugated throughout their whole length.

This apparatus is fully described in catalogue No. 14.

AMERICAN WATER SOFTENER CO.

1005 CHESTNUT STREET
PHILADELPHIA, PA.

WATER SOFTENING PLANTS; PRESSURE AND GRAVITY FILTERS.

WATER SOFTENING PLANTS

Our Water Softening System, because of its simplicity, its mechanically automatic accuracy and its immediate response to any change of chemical feed adjustment required for a change in quality of raw or crude water, is very effective, economical and accurate. This space is too limited to give details of operation or construction or views of installations made for some of the largest industries and railroads of the country. These are covered by our catalogue and a reprint from Engineering News of an article on "Economies from Water Softening on the Florida East Coast Railway."

SCHEDULE OF CAPACITIES AND SIZES

Capacity per Hour Gal.	Cold Water Plants						Maximum Head Room		Hot Water Plants						Maximum Head Room	
	Width		Heighth		Length				Width		Heighth		Length			
	Ft.	In.	Ft	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.		
50	3	0	3	6	4	0	5	6	2	0	3	6	3	0	5	6
100	3	6	4	0	5	0	6	0	3	0	3	6	4	0	5	6
200	4	6	5	0	5	6	7	0	3	6	4	0	5	0	6	0
300	5	0	6	0	6	6	8	6	4	0	5	0	5	0	7	6
400	6	0	6	6	7	0	9	0	4	6	5	3	5	6	7	9
500	6	0	7	0	8	0	9	6	5	0	6	0	6	0	8	6
600	6	6	7	0	9	0	9	6	5	0	6	3	6	6	8	9
700	6	6	7	6	9	0	10	0	6	0	6	3	6	6	8	9
800	7	0	8	0	9	0	11	0	6	0	6	6	7	0	9	6
900	7	0	8	6	10	0	11	6	6	0	6	6	8	0	9	6
1000	7	6	8	6	10	0	11	6	6	0	7	0	8	0	10	0

The tank dimensions of any machine may be changed to suit available space, it only being necessary to keep the relative cubical capacities constant. For Softeners of larger capacity than 1000 gal. per hr. we recommend our cylindrical type.

WATER FILTERS

We manufacture and install Gravity and Pressure Water Filters of any capacity and for every service, as well as plants for removing iron from water supplies. These filters are simple and durable and have a low upkeep cost. Estimates, advice and water analyses without charge.

SIZES AND CAPACITIES OF STYLE NO. 11 FILTERS

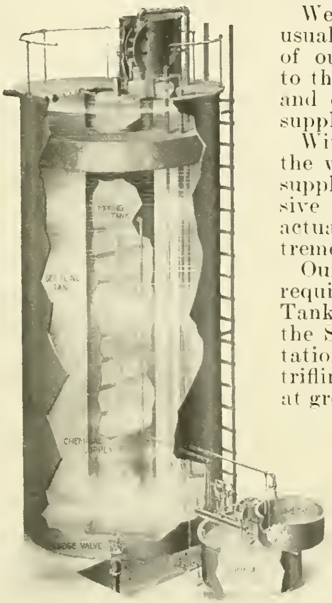
Diameter Ft.	Inlet and Outlet Pipes, In.	Waste Pipe In.	Capacity per Hour Gal.
6	3	4	3360–5040
6½	3	4	2960–5940
7	4	5	4680–6900
8	4	5	6000–9000

L. M. BOOTH COMPANY

136 LIBERTY STREET, NEW YORK, N. Y.

WATER SOFTENERS FOR PURIFICATION OF WATER FOR BOILER FEED, LAUNDRY, INDUSTRIAL AND POTABLE USES GENERALLY.

BOOTH WATER SOFTENERS



Type F Booth Water Softener

We furnish complete plants including the usual steel or concrete settling tank. Branches of our engineering department are devoted to the design and construction of mechanical and operating equipment of municipal water supply purification plants.

With a knowledge at hand of character of the water and of conditions surrounding its supply and use, we can formulate comprehensive warrantys. This is possible because in actual service our softeners operate with extreme accuracy and there is no waste.

Our precise Chemical Regulator delivers the required amount of chemical; in the Mixing Tank the water is softened and coagulated; the Settling Tank affords quiet for sedimentation. The net result is clear soft water at trifling cost. No climbing. All operating parts at ground level.

OPERATION

In the Type "F" softener which is illustrated, the chemicals for purification, usually quick lime and soda ash, are prepared at ground level. Sufficient lime to last twelve hours is slaked in the lime tank and discharged through a screen into the Chemical Tank. If hydrated lime is used, this is thrown directly into the Chemical Tank with the soda ash, where very thorough agitation dissolves the soda and keeps the lime suspended in the mixture. From the Chemical Tank the chemicals are automatically measured and fed into the top of the Mixing Tank. The raw water enters through the inlet pipe and discharges onto an overshot wheel at top of softener, furnishing power for operating the paddles in the Mixing Tank, as well as that required to operate the Chemical Pumps and the Agitators in the Chemical Tank.

After passing over the Water Wheel the water flows into the top of the Mixing Tank where it meets the chemicals delivered from the automatic chemical regulator located on the Chemical Tank at the ground level. The supply of chemicals is automatically regulated in proportion to flow of water. No small orifices to stop up are employed. Only large openings under very slight head are used.

While passing slowly down through the Mixing Tank, the water and chemicals are thoroughly stirred together by the paddles.

After leaving the Mixing Tank at the bottom, the water flows slowly upward in the Settling Tank, deposits precipitate and flows through a wood filter to the outlet, soft and pure. The precipitate deposited in the Settling Tank is removed by our patented sludge disposal system controlled by the valve shown.

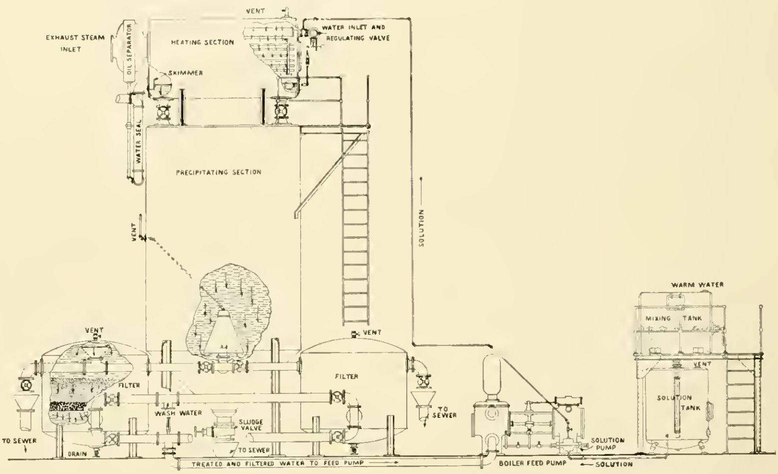
POWER PLANT SPECIALTY CO.

MONADNOCK BLOCK, CHICAGO, ILL.

VATER WATER SOFTENING AND HEATING SYSTEM; VATER OPEN HEATER; VATER TWO-STAGE SEPARATOR; MONARCH VACUUM DRAINER.

THE VATER WATER SOFTENING AND HEATING SYSTEM

With Independent Filtration



This system consists essentially of:

Mixing and Solution Tanks for preparing solution, conveniently arranged for operating and sufficiently large in capacity to permit of a dilute solution being used in order that the strength will not be affected by local temperature conditions.

Solution pump delivers chemicals from solution tank to raw water inlet on heating section. This pump is double acting, outside end packed, and is driven from the motion of the boiler feed pump with attachments arranged so that the chemical feed may be varied to suit the water to be treated.

Heating Section: This part of the system comprises all the features regularly found in first class open feed water heaters: that is, oil separator, float-operated regulating valve, skimmer, overflow trap, distributing box, trays, doors for access to the interior, platform and ladder. In this section the raw water is heated to the highest attainable temperature with the exhaust steam available, and thoroughly mixed with the chemicals. It then passes through the valved openings to the precipitating tank below.

The precipitating tank is built sufficiently large to give the chemicals ample time to react on the scale-forming matter. It is fitted with a hooded outlet to the filters in order to cause the heavy precipitate to settle as far as possible in the cone shaped bottom, from whence it is blown out through the sludge valve.

The filters which receive and clarify the softened, though somewhat dirty, water from the precipitating tank, are usually two in number, and are of the quartz pressure type. They are fitted with the usual parts consisting of inlet, outlet, blow-off, vent and wash water openings, strainers, hood and crushed quartz.

The water after leaving these filters is crystal clear, in addition to being thoroughly soft and free from scale-forming matter.

The salient features of this system are:

Highest efficiency in heating water by means of exhaust steam. An absolutely accurate proportioning of the chemicals to the raw water.

Precipitation at such a temperature and for a sufficient time to get perfect results without a large excess of chemicals.

Perfect filtration, giving a crystal clear water.

Minimum cost of attendance and chemicals.

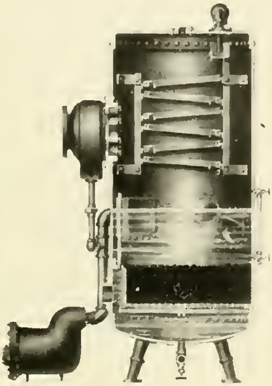
Minimum space required for installation.

POWER PLANT SPECIALTY CO.

CHICAGO, ILLINOIS

THE VATER FEED WATER HEATER AND THE VATER SEPARATOR

THE VATER OPEN FEED WATER HEATER



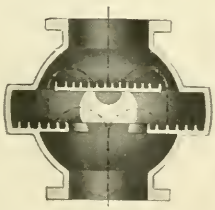
The "Vater" open heater is built in the vertical and monitor forms in sizes from 200 H.P. to 2000 H.P., and in the horizontal form from 1000 H. P. upward.

It comprises the best features regularly found in first class heaters and is constructed to give the best heating effect, to be easily accessible and to cost the minimum for repairs. Only first class material, and plenty of it, and the best of trimmings are used.

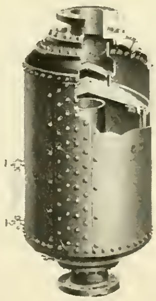
They have a liberal tray area and liberal water storage, giving a liberal overload rating.

Our Catalog gives a detailed description.

THE VATER TWO-STAGE SEPARATOR



Section of Separating Element



This separator is built in forms to suit all services. It is called a two-stage separator, because the separating element is designed with two compartments, one having a considerably larger cross-sectional area than the other. The ports in the baffle plates are staggered. This construction gives two precipitations at two different steam speeds, the last of which is at the lower speed, resulting in exceptionally high efficiency. It is impossible for moisture or oil to pass through without impinging on a baffle plate.

As for the mechanical construction, only the best material and workmanship are employed. For the high-pressure separators we use a metal having a tensile strength of from 30,000 to 40,000 pounds, and for the steel plate wells we use a double butt-strapped and triple-rivetted longitudinal seam. Every separator is given a thorough pressure test before shipment and is guaranteed to stay tight.

THE SIMS COMPANY

ERIE, PENNSYLVANIA

POWER PLANT APPLIANCES, FEED WATER HEATERS, HOT WATER GENERATORS, ETC.

We issue catalogs covering our large variety of sizes and product and we incorporate valuable data for the use of the engineer. Column A of table below gives catalog number, Column B the maximum usual pressure for the apparatus, Column C the sizes made.

A	STOCK TITLE	B	C
TH2	Tubular (or closed) Feed Water Heaters. See Figs. 6 and 7	150	25
OH2	Open Feed Water Heaters and Purifiers. Fig. 5	15	15
G2	Hot Water Generators (For heating water)	50	25
M2	Sheet Iron Exhaust Heads. Fig. 2	?	21
M2	Cast-Iron Exhaust Heads		16
M2	Boiler Compound Feeders	150	5
	Sugar Juice Heaters	50	10
SS2	Steam Separators—Vertical, See Fig. 1. Horizontal, See Fig. 4	150	13
M2	Water Softeners	150	2
M2	Oil Separators Fig. 3	20	16
M2	Oil Filters		11
	Boiler Cleaners	150	3
M2	Low Water Alarms	150	1
G2	Convertors (For heating by hot water)	50	25

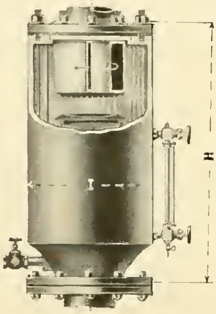


Fig. 1

Fig. 2

Fig. 3

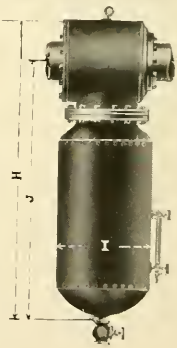


Fig. 4

Table for Fig. 5						Table for Fig. 1			Table for Fig. 4			
D	E	F	O	H	I	Dia. Pipe K	H	I	Dia. Pipe K	H	I	J
4	200	8	$1\frac{1}{2}$	87	25	$2\frac{1}{2}$	16	$8\frac{1}{2}$				
5	300	8	$1\frac{1}{2}$	73	29	3	19	$10\frac{1}{2}$	3	$39\frac{1}{4}$	12	34
6	400	10	2	90	29	$3\frac{1}{2}$	19	$10\frac{1}{2}$	$3\frac{1}{2}$	$39\frac{1}{4}$	12	34
7	500	10	2	92	35	4	20	12	4	42	14	36
8	600	12	2	104	35	$4\frac{1}{2}$	20	12	$4\frac{1}{2}$	42	14	36
9	800	14	3	73	43	5	22	14	5	49	16	42
10	1000	14	3	96	43	6	23	15	6	$55\frac{1}{2}$	18	48
11	1200	16	3	112	43	7	30	$16\frac{1}{2}$	7	$64\frac{1}{4}$	22	56
12	1500	16	3	133	43	8	30	21	8	$70\frac{1}{2}$	22	60
13	2000	20	4	168	43	9	33	22	9	81	26	70
14	2500	20	4	122	64	10	33	23	10	$87\frac{1}{2}$	26	76
15	3000	22	5	145	64	12	34	24	12	96	30	84

NOTE. Smaller sizes are made in all the apparatus given in tables and several variations from each type are possible to suit conditions.

THE SIMS COMPANY

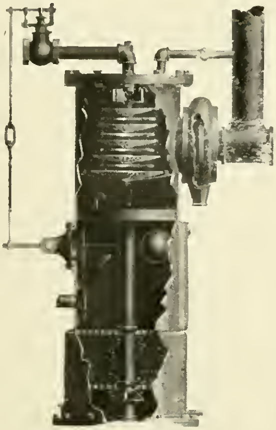


Fig. 5

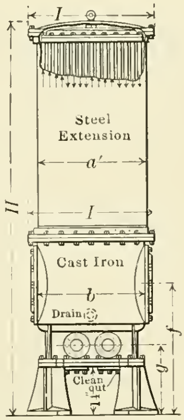


Fig. 6

Fig. 7

NOTE. The index letters given in the table refer to the dimensions given on the various apparatus illustrated above. Column D = Stock number. Column E = Horse Power Rating. Column F = Dia. of Exhaust. Column G = Water Connections. Column H = Total Height. Column I = Greatest Diameter. Column O = steam supply. All dimensions in inches.

TABLE FOR FIGURES

D	E	F	G	H	I	a′	e′	f	g	h
10	200	8	2	66	25	17		24½	12	26
11	250	8	2	78	25	17		24½	12	35
12	300	8	2½	90	25	17		24½	12	57
13	400	10	3	87	30	20		32	15	35
14	500	10	3	99	30	20		32	15	47
15	600	12	3	111	30	20		32	15	59
16	700	12	3	123	30	20		44	15	59
17	800	14	4	103	43	37	48½	40	20	
18	900	14	4	111	43	37	56½	40	20	
19	1000	14	4	119	43	37	64½	40	20	
20	1200	16	4	139	43	37	84½	40	20	
21	1500	16	4	166	43	37	112½	40	25	
22	2000	20	5	167	48½	41½	99	50	26½	
23	2500	20	5	195	48½	41½	127	50	26½	
24	3000	22	5	216	48½	41½	148	50	26½	
25	4000	22	6	260	48½	41½	191	50	26½	

STEWART HEATER CO.

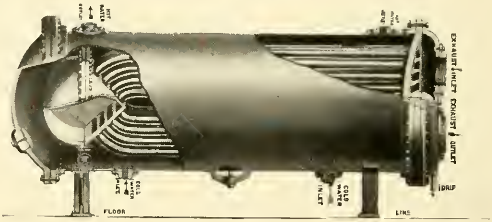
BUFFALO, NEW YORK

THE OTIS TUBULAR FEED WATER HEATER, OIL SEPARATOR AND PURIFIER; THE OTIS LIVE STEAM WATER HEATER, AND THE OTIS DOUBLE SYSTEM OR COMBINATION WATER HEATER.

THE OTIS TUBULAR FEED WATER HEATER, OIL SEPARATOR AND PURIFIER.

This heater can be used with either exhaust or live steam. It not only heats the feed water but cleanses it of all impurities, removes the scum from the surface and the heavy deposit that falls to the bottom. The heater does not fill up with scale because the settling chamber at the bottom remains comparatively cool. All the moisture and oil is removed from the steam, the condensation purified and returned to the boiler.

Vertical Type



Horizontal Type

DIMENSIONS OF THE VERTICAL TYPE HEATER.

NOTE.—The horizontal type have same diameter as the vertical but are a few inches shorter. The number given to the heater in the table is the largest diameter of exhaust pipe the heater is adapted for. The heating surface given is the actual heating surface of the tubes and water separator.

No. of Heater (Size of Exhaust)	Horse Power	Size in Inches	No. of Tubes	Sq. Ft. Htg. Surf.	Dia. Feed Pipe	Weight
4	30	15 x 48	14	16	1¼″	560
A4	40	15 x 60	14	23	1¼	620
B4	50	15 x 72	14	30	1¼	680
C4	60	15 x 84	14	36	1¼	740
6	100	20 x 72	24	53	1½	1090
A6	125	20 x 84	24	66	1½	1170
B6	150	20 x 96	24	80	1½	1260
7	160	25 x 72	48	83	2	1540
A7	200	25 x 84	48	105	2	1670
8	250	25 x 96	48	150	2	1790
A8	300	25 x 108	48	170	2	1920
9	350	30 x 108	52	176	2½	2480
A9	400	30 x 120	52	205	2½	2630
10	450	35 x 120	52	225	3	3400
A10	500	35 x 132	52	257	3	3600
B10	550	35 x 144	52	290	3	3800
12	600	40 x 132	60	319	3½	6500
A12	700	40 x 144	60	361	3½	6750
B12	800	40 x 156	60	403	3½	7000
16	900	45 x 144	56	444	4	9400
A16	1000	45 x 156	56	494	4	9800
B16	1100	45 x 168	56	551	4	9900
18	1150	54 x 144	86	568	5	14400
A18	1250	54 x 156	86	643	5	14900
B18	1400	54 x 168	86	720	5	15400
C18	1500	54 x 180	86	796	5	15900
D18	1700	54 x 192	86	872	5	16400

THE LOMBARD GOVERNOR CO.

ASHLAND, MASS.

HYDRAULIC GOVERNORS FOR ALL PRIME MOVERS; WATER RELIEF VALVES, MECHANICALLY AND HYDRAULICALLY OPERATED; SPEED-RECORDING AND INDICATING INSTRUMENTS; WATER-LEVEL RECORDERS AND FREQUENCY RECORDERS.

STANDARD GOVERNORS

Type	Style	Capacity in ft. lbs. per stroke	Shipping Weight in pounds	Time of stroke in seconds
F	Horizontal	2,500	2,000	1
R	Vertical	2,500	2,550	1
M	Horizontal	4,500	2,500	2
P	Horizontal	6,700	2,500	3
PS	Horizontal	6,700	2,600	1
R6″	Vertical	6,700	3,150	3
Q6″	Vertical	6,700	3,250	1
O6″	Horizontal	10,000	3,000	4
OS6″	Horizontal	10,000	3,100	1
R7½″	Vertical	10,000	3,400	4
Q7½″	Vertical	10,000	3,500	1
O7½″	Horizontal	16,000	3,250	4
OS7½″	Horizontal	16,000	3,350	1
Q10″	Vertical	20,000	7,300	1
NS	Vertical	30,000	7,500	2
N14″	Vertical	60,000	11,500	3

Special types built to order and to meet special requirements.

GOVERNOR ACCESSORIES

Electric Speed Controls of various types for manipulation of governors from switchboards or any distant points.

Safety Emergency Stop device; can be arranged for distant control.

Pressure-Control Mechanism for governing at variable speed and constant pressure of air or water.

Pipe Line Pressure-Equalizing Device, for reducing water hammer.

Water Relief Valves, in sizes 3″ to 23″, to meet all requirements.

Precision Tachometer, 10″ dials; scales calibrated to order.

Speed Recorder for permanent and accurate records.

Electrical Long Distance Speed Indicators, for transmitting speed indications to any point.

Frequency Recorders for permanent and accurate records.

Water-Level Recorders; draws large scale curves.

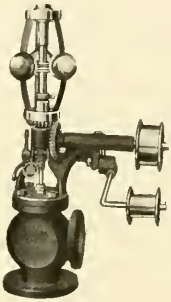
THE PICKERING GOVERNOR CO.

PORTLAND, CONNECTICUT

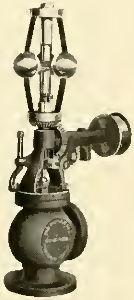
GOVERNORS FOR STEAM ENGINES, GAS ENGINES, STEAM TURBINES, MECHANICAL CONTROL AND POWER REGULATION.

Owing to the absence of joints our Governors are very responsive to small changes in load, moving quickly and positively into correct position for maintaining the admission of steam proportionate to the duty required of the engine. Absence of joints gives maintenance in efficiency under continued and severe duty.

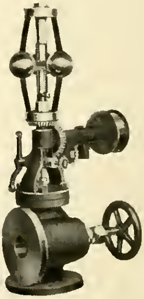
Speed Rangers are incorporated, permitting wide range in adjustment of Engine speed while running.



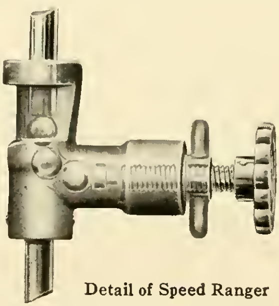
Class A



Class B Vertical

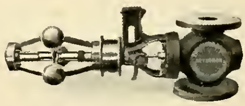


Gov. with Stop Valve



Detail of Speed Ranger

Class A Governors are equipped with safety stop which shuts off steam from the engine if governor drive belt should break. Class B are not equipped with safety stop. Horizontal B is never provided with safety stop. Governor with stop valve does away with joint between governor and valve.



Class B Horizontal

TABLE OF DIMENSIONS, ETC., FOR CLASSES A AND B

Diameter of Opening Size of Governor	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6	7	8	9	10
From center of inlet to base...	$3\frac{1}{4}$	$3\frac{1}{2}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$5\frac{1}{16}$	$5\frac{1}{2}$	$6\frac{1}{4}$	$7\frac{7}{16}$	$7\frac{5}{16}$	8	$8\frac{9}{16}$	9	10	$11\frac{1}{2}$	$11\frac{1}{2}$
Extreme Height..............	$20\frac{3}{16}$	$23\frac{31}{32}$	$25\frac{3}{32}$	$27\frac{1}{4}$	$27\frac{13}{16}$	$32\frac{5}{16}$	$33\frac{13}{16}$	$41\frac{5}{32}$	$41\frac{5}{32}$	$46\frac{1}{2}$	$49\frac{1}{8}$	$49\frac{3}{8}$	$53\frac{7}{8}$	$55\frac{7}{8}$	$60\frac{3}{4}$
Extreme expansion of Balls..	7	8	8	9	9	10	10	13	13	15	$16\frac{1}{2}$	$16\frac{1}{2}$	18	20	20
Speed of Governor..........	350	380	380	300	300	340	340	320	320	275	275	275	260	260	225
Dia. of Pulley on Gov.......	$2\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	4	4	4	4	5	5	5	6	7	7	8	8
Dia. of Cyl. 300 ft. Piston Sp..	6	7	9	10	12	14	16	18	20	22	26	31	36	40	45
" " " 400 " " "	5	6	8	9	10	12	14	16	18	20	23	27	31	35	39
" " " 500 " " "	$4\frac{1}{2}$	5	7	8	9	10	12	14	16	18	21	24	28	31	35
" " " 600 " " "	4	$4\frac{1}{2}$	6	7	8	9	11	13	15	16	19	22	25	28	32

For complete table and for sizes below $1\frac{1}{4}$--see our general catalogue.

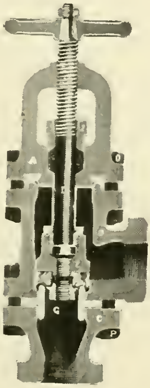
A. W. CADMAN MANUFACTURING CO.

Cable Address "Cadman"—W. U. Code Used

PITTSBURG, PA.

STEAM BOILER SPECIALTIES, BEARING METAL AND SPECIAL CASTINGS

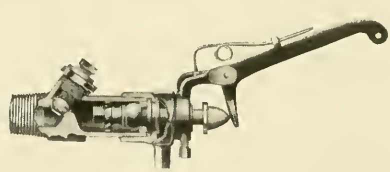
Indestructible Blow Off Valves. Indestructible Gage Cocks. Indestructible Check Valves. Ball Valves. Gage Cocks. Split Plug Valves (Will not bind). Patent Coke Oven Valves. Champion Feed Water Heater. Aluminum Babbitt Metal ("Acorn Brand"). Homestead Babbitt Metal O. K. Bearing Metal. Brass, Bronze and Aluminum Castings. Brass-Bound Solid Copper Reversible Disc Plate.



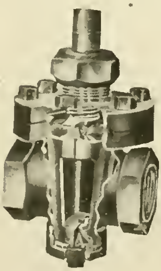
INDESTRUCTIBLE BLOW-OFF VALVE

Cadman's Blow-Off Valve overcomes the weak points in valve discs and the screwed-in seats. To repair this valve all that is required is to reverse the disc or seat or both. This can be done quickly. The disc is a brass-bound solid copper plate, reversible and may be refaced in an ordinary lathe. The use of copper makes the valve durable in hot soda compounds of boiler feed water. The seat is arranged to clamp between the valve body and base to prevent leakage past the seat and for convenience in removing for reversal or refacing. This is accomplished without removing body from position. The face of the seat is located to permit a thin stream of water to wash the face of disc and seat as the valve closes. It is made $1\frac{1}{4}''$–$1\frac{1}{2}''$–$2''$–$2\frac{1}{2}''$–$3''$ and $4''$, with or without flanged ends.

INDESTRUCTIBLE GAUGE COCK



Cadman's indestructible gauge cock is an improvement on the well-known Mississippi type. The tendency to clog up with scale is overcome by having the valve seat some distance from the boiler, away from heat, and stopping the circulation in the cock when not blowing. It is provided with a positive outside shut off which permits repairs to the cock while boiler is under pressure. Valve and seat are both reversible and renewable, and several other features add to the life of the cock.



SPLIT-PLUG VALVE

Cadman's Split-Plug Valve is a new quarter-turn, quick-opening plug valve that will not stick or bind when opening or closing under pressure.

The plug is split almost through, and is forced out against the inner walls of the body, when closing, by the pointed screw stem and wedge-shaped expander in the bottom of body. It is adjustable, to compensate for wear. Made in all sizes, either all iron or brass, or iron body with brass plug and stem.

THE KENNEDY VALVE MFG. CO.

ELMIRA, NEW YORK

VALVES FOR VARIOUS PURPOSES AND PRESSURES; COMPANION FLANGES; HYDRANTS AND EXTENSION VALVE BOXES; INDICATOR POSTS AND FLOOR-STANDS; INDICATOR DEVICES, ETC.

The Kennedy valve catalog for 1910 contains in its 114 pages complete information regarding our product. Upon these two pages we illustrate several important types of valves and data for valves in general use giving only alternate sizes. The intermediate sizes may be closely approximated by interpolation. Note that we use gearing on valves 30 inches and larger unless instructed otherwise. By-pass on 42″ and 48″ unless otherwise ordered. Sizes of valves advance as follows: $\frac{1}{4}$″, $\frac{3}{8}$″, $\frac{1}{2}$″, $\frac{3}{4}$″, 1″, $1\frac{1}{4}$″, $1\frac{1}{2}$″, 2″, $2\frac{1}{2}$″, 3″, $3\frac{1}{2}$″, 4″, $4\frac{1}{2}$″, 5″, 6″, 7″, 8″, 9″, 10″, 12″, 14″, 16″, 18″, 20″, 24″, 30″, 36″, 42″, 48″, dimensions given being the standard size of pipe to which the valve applies.

REFERENCE LETTERS

Face to face, Screwed.............A
Face to face, Flanged ....B
Face to face, Flg. with by-pass....C
Center to top of wheel, I. S.......D
Center to top of stem.O.S.&Y.(open)E
Width across cap flange ....F

BRONZE GATE VALVES

STANDARD

Working pressure $\frac{1}{4}$″ to 3″ water=150 pounds, steam = 125 pounds. $3\frac{1}{2}$″ to 6″ water=125 pounds, steam =100 pounds. Screwed $\frac{1}{4}$″ to 4″ flanged = 2″ to 6″. Inside screw $\frac{1}{4}$″ to 6″, outside screw $\frac{3}{4}$″ to 2″.

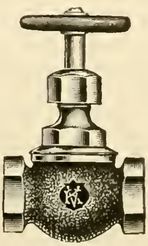
MEDIUM HEAVY

Made in sizes $\frac{1}{2}$″ to 3″ screwed working pressure, water=250 pounds, steam=200 pounds. Inside screw, with iron wheel. Gland follower in stuffing box.

"STANDARD" IRON BODY BRONZE MOUNTED GATE VALVES

Double discs, parallel seats, inside or outside screw and yoke. Working pressure, water, $1\frac{1}{2}$″ to 8″=150 pounds, 9″ to 14″ =125 pounds, 16″ to 48″=100 pounds; Steam, $1\frac{1}{2}$″ to 8=125 pounds, 9″ to 14″=100 pounds.

Pipe Size	2	3	4	6	8	10	12	16	20	24	30	36	42	48
A	5	$6\frac{1}{4}$	7	$8\frac{5}{8}$	$10\frac{1}{4}$	$11\frac{1}{2}$	$13\frac{1}{4}$	....	....	....	....	....	....	....
B	6	$7\frac{3}{4}$	$8\frac{5}{8}$	$10\frac{1}{8}$	$11\frac{1}{4}$	$12\frac{5}{8}$	$13\frac{1}{2}$	$14\frac{3}{8}$	16	$17\frac{3}{4}$	27	$26\frac{1}{2}$	....	....
C	....	....	....	....	....	....	....	$20\frac{1}{8}$	$21\frac{1}{2}$	23	27	$29\frac{1}{4}$	$34\frac{1}{2}$	40
D	$9\frac{1}{2}$	$11\frac{7}{8}$	$14\frac{1}{4}$	$18\frac{3}{8}$	$22\frac{5}{8}$	$25\frac{3}{8}$	29	$37\frac{1}{2}$	$44\frac{3}{4}$	54	$68\frac{3}{4}$	$78\frac{3}{4}$	$90\frac{1}{2}$	102
E	....	$17\frac{1}{8}$	$20\frac{5}{8}$	30	40	$44\frac{7}{8}$	55	$69\frac{1}{4}$	$85\frac{3}{4}$	$102\frac{1}{4}$	$126\frac{1}{4}$	$147\frac{1}{2}$	$169\frac{5}{8}$	$197\frac{1}{2}$
F	$5\frac{3}{8}$	$6\frac{13}{16}$	$8\frac{1}{4}$	$11\frac{3}{16}$	$14\frac{5}{16}$	$16\frac{9}{16}$	$18\frac{15}{16}$	25	29	$35\frac{1}{2}$	46	50	60	$68\frac{1}{2}$



"MEDIUM HEAVY" IRON BODY BRONZE MOUNTED GATE VALVES

"Lenticular" Double discs, taper seats, inside or outside screw and yoke. Self-packing feature on both inside and outside screw valves, suitable for working steam pressures up to 160 pounds and up to 200 pounds water.

Pipe Size	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6	7	8	10	12	14
A	$6\frac{3}{8}$	$7\frac{1}{2}$	$8\frac{3}{8}$	$9\frac{3}{8}$	$9\frac{3}{4}$	$10\frac{1}{4}$	$11\frac{3}{8}$	12	$12\frac{1}{2}$	$13\frac{7}{8}$	$14\frac{3}{4}$	......
B	$9\frac{1}{8}$	$9\frac{1}{2}$	$10\frac{1}{2}$	$10\frac{5}{8}$	$11\frac{3}{4}$	$12\frac{1}{8}$	$13\frac{1}{4}$	$13\frac{1}{4}$	$13\frac{1}{4}$	$14\frac{3}{8}$	$15\frac{3}{4}$	$17\frac{1}{2}$
C	......	......	......	......	......	$12\frac{1}{8}$	$13\frac{1}{4}$	$13\frac{1}{4}$	$13\frac{1}{4}$	$14\frac{3}{8}$	$15\frac{3}{4}$	$17\frac{1}{2}$
D	$11\frac{1}{4}$	$12\frac{1}{2}$	$13\frac{1}{2}$	$14\frac{1}{2}$	$16\frac{1}{4}$	$18\frac{5}{8}$	$21\frac{1}{4}$	$23\frac{1}{2}$	$25\frac{5}{8}$	$20\frac{1}{2}$	35	37
E	$15\frac{3}{4}$	$17\frac{3}{4}$	$20\frac{1}{2}$	$22\frac{1}{2}$	$25\frac{3}{4}$	$29\frac{1}{4}$	$34\frac{1}{2}$	33	42	$51\frac{1}{2}$	59	66

"EXTRA HEAVY" IRON BODY BRONZE MOUNTED GATE VALVES

"Lenticular" Type—Double Discs; Taper Seats; Inside or Outside screw and yoke, with self-packing feature, suitable for working steam pressures up to 250 pounds and up to 300 pounds water.

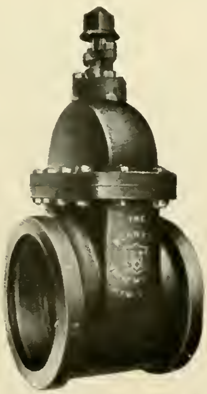
Pipe Size	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	5	6	7	8	10	12	14	16	18	20
A	9	10	$10\frac{1}{2}$	$10\frac{3}{4}$	$13\frac{1}{4}$	$13\frac{3}{4}$	$14\frac{1}{2}$	$15\frac{3}{4}$	......	......	......	......	......	......
B	10	$11\frac{5}{8}$	$11\frac{7}{8}$	$12\frac{1}{4}$	15	$15\frac{7}{8}$	$16\frac{1}{2}$	$16\frac{1}{2}$	18	$19\frac{1}{2}$	$21\frac{1}{2}$	$21\frac{1}{2}$	22	25
C	......	......	......	......	15	$15\frac{7}{8}$	$16\frac{1}{2}$	21	$22\frac{1}{2}$	$23\frac{3}{4}$	$25\frac{7}{8}$	29	32	$35\frac{1}{4}$
D	$12\frac{3}{4}$	$13\frac{1}{2}$	$15\frac{5}{8}$	$16\frac{1}{4}$	$19\frac{3}{8}$	21	$22\frac{7}{8}$	$25\frac{1}{8}$	$28\frac{7}{8}$	34	$37\frac{3}{8}$	$41\frac{1}{2}$	$47\frac{1}{2}$	$49\frac{3}{4}$
E	$16\frac{5}{8}$	$18\frac{7}{8}$	$22\frac{1}{4}$	$23\frac{7}{8}$	$29\frac{1}{2}$	$33\frac{1}{4}$	37	$41\frac{1}{4}$	49	$60\frac{3}{4}$	$67\frac{1}{4}$	75	83	93

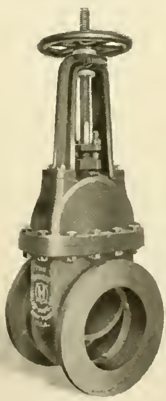
THE "NEWTYPE" IRON BODY BRONZE MOUNTED WATER GATE VALVES

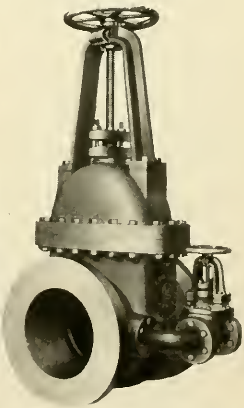
Double discs, parallel seats; bell ends; for underground mains. This valve is our latest design and is made on generous lines to meet the requirements of the most prominent water-works engineers and superintendents in the country. Working pressure 8″ and smaller = 200 pounds, 10″ to 48″ = 150 pounds.

End to end without by-pass.......A
End to end with by-pass..........B
Center to top of nut...............C
Length of cap flange ....D
Diameter of bell ....E
Depth of bell.......................F

Pipe Size	4	8	12	16	20	24	30	36	42	48
A	$12\frac{3}{8}$	$13\frac{1}{2}$	$15\frac{3}{4}$	$18\frac{1}{8}$	$18\frac{5}{8}$	21	$27\frac{1}{2}$	$32\frac{3}{4}$	35	36
B	......	......	......	......	......	26	$27\frac{1}{2}$	$22\frac{3}{4}$	35	36
C	$16\frac{5}{8}$	$24\frac{1}{8}$	$32\frac{1}{2}$	40	$47\frac{1}{2}$	55	$72\frac{1}{4}$	$81\frac{3}{4}$	$92\frac{1}{4}$	$102\frac{1}{4}$
D	$9\frac{3}{8}$	$14\frac{5}{16}$	$19\frac{7}{16}$	25	$29\frac{3}{8}$	$35\frac{1}{2}$	$47\frac{1}{8}$	$51\frac{1}{2}$	60	$67\frac{1}{2}$
E	$5\frac{11}{16}$	10	$14\frac{1}{4}$	$18\frac{5}{8}$	$22\frac{1}{2}$	$26\frac{5}{8}$	33	$39\frac{5}{16}$	$45\frac{1}{2}$	$51\frac{13}{16}$
F	4	4	$4\frac{1}{2}$	5	5	5	5	5	5	5







THE LUDLOW VALVE MFG. CO.

TROY, NEW YORK

HIGH GRADE VALVES FOR EVERY PURPOSE; VALVES FOR OIL, WATER, STEAM, GAS AND AMMONIA, OF ANY SIZE AND FOR ALL PRESSURES; AUTOMATIC AIR VALVES AND FLOAT VALVES; RELIEF VALVES; SLUICE GATES; CHECK AND FOOT VALVES; COMBINATION AIR VALVE WITH CONTROLLING GATE; HYDRANTS.

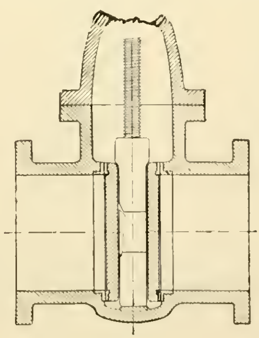
In the table below is given a partial list of our product. Column A gives the page in our 1910 catalogue upon which the valve is listed, column B the recommended maximum working steam pressure, column C the sizes made.

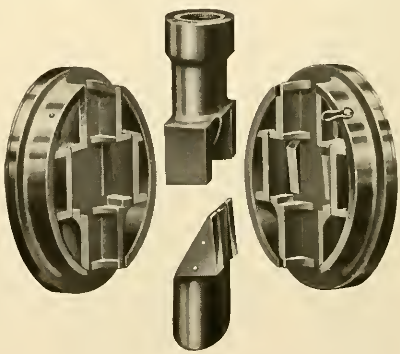
A	STOCK TITLE	B	C
24	Iron Body Gate, Bronze Mounted and all Iron Single Gate	30–35	1½" to 12"
32	Double Gates, Iron Body Bronze Mtd. and all Iron	25–30	14" to 72"
36	Double Gates, " " " " " " " "	70–75	1" to 12"
38	" " " " " " " " " "	80–85	2" to 12"
39	" " " " " " " " " "	115–125	2" to 20"
40	" " " " " " " " " "	225–250	1½" to 24"
44	" " " " " "	75	14" to 60"
60	" " " " " " and all iron	* 750	1" to 12"
62	" " " " " " " " " "	* 1200	1½" to 12"
65	Single " " " " " Light Water Valve	* 15 to 20	14" to 78"
16	Double Gates, All Bronze	75 to 125	⅜" to 12"
18	" " " "	200 to 250	⅜" to 6"
75	Sluice Gates, Circular, Square or Rectangular,		6" to 84"
	Double Gate with Bevel gear, all lists and sizes		
	" " " Outside Rising Stem and Yoke all lists and sizes		
	" " " Bypass all lists and sizes		
24	Quick opening Gate Valve—Single Gate		1½" to 12"
36	" " " " Double "		1" to 12"
16	" " " " Double Gate, Bronze		⅜" to 12"

* Water.

THE LUDLOW DOUBLE GATE VALVE

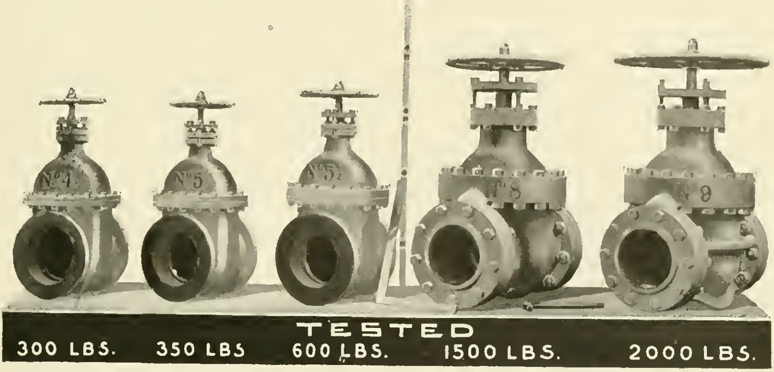
The illustrations below show section of valve and detailed view of the Gates and Wedges. The Gates cannot lock or wedge in closing until directly opposite the ports. Gates are released from seats before starting to rise avoiding wear on seats and grinding or dragging of faces of gates on seats is impossible. Stem cannot bind or wedge. The gates cannot cant to either side and cause slipping of threads on stem.





LUDLOW DOUBLE GATE VALVES FOR ALL PRESSURES

These Valves all have a 10″ opening



DIMENSIONS OF IRON BODY BRONZE MOUNTED VALVES

Face-to-face flanges = A. Diameter of flange = Q.

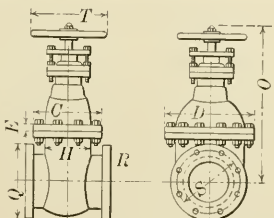
Diameter and Drilling flanges these Valves to A.S.M.E. Standard adopted July 18, 1894.

Sizes		3	4	5	6	8	10	12	14	16	18	20	24
Page 24 List 1	A	$6\frac{7}{8}$	$8\frac{1}{4}$	$10\frac{3}{4}$	$11\frac{1}{8}$	11	$12\frac{3}{8}$	$12\frac{7}{8}$	...	...	...	...	...
Page 36 List 4	A	$6\frac{7}{8}$	$8\frac{1}{4}$	$10\frac{3}{4}$	$11\frac{1}{8}$	11	$13\frac{3}{4}$	$14\frac{5}{8}$	...	...	...	...	...
Page 38 List 5	A	8	$8\frac{5}{8}$	$10\frac{3}{4}$	$11\frac{1}{8}$	$13\frac{1}{4}$	15	$15\frac{1}{2}$	...	...	...	...	...
Page 39 List $5\frac{1}{4}$	A	8	$8\frac{5}{8}$	$10\frac{3}{4}$	$11\frac{1}{8}$	$13\frac{1}{4}$	15	$15\frac{1}{2}$	...	...	...	...	...
Page 44 List 6	A	...	...	...	...	...	...	...	$15\frac{3}{4}$	16	17	$17\frac{3}{4}$	21

Diameter and Drilling flanges these Valves to Manufacturer's Extra Heavy Standard adopted June 28, 1901.

Sizes		3	4	5	6	8	10	12	14	16	18	20	24
Page 40 List $5\frac{1}{2}$	A	$9\frac{1}{4}$	$9\frac{1}{2}$	$12\frac{1}{8}$	13	$14\frac{1}{4}$	$16\frac{3}{4}$	$17\frac{1}{2}$	19	23	25	$26\frac{1}{2}$	$29\frac{1}{8}$

Sizes		3	4	5	6	8	10	12	14	16	18	20	24
Page 60 List 8	A	$11\frac{1}{2}$	$12\frac{7}{8}$	19	$18\frac{1}{2}$	$21\frac{7}{8}$	$27\frac{5}{8}$	$33\frac{7}{8}$	...	...	...	...	...
	Q	9	10	12	12	15	$19\frac{1}{2}$	24	...	...	...	...	...
Page 62 List 9	A	$12\frac{3}{4}$	19	$21\frac{1}{2}$	22	$30\frac{3}{8}$	$27\frac{5}{8}$	...	...	...	...	...	...
	Q	10	12	13	14	$19\frac{1}{2}$	$19\frac{1}{2}$	...	...	...	...	...	...
Page 32 List 3	A	...	...	...	...	...	...	...	$13\frac{3}{4}$	$13\frac{7}{8}$	$14\frac{1}{16}$	$15\frac{1}{2}$	17
	Q	...	...	...	...	...	...	...	20	22	24	26	31
Page 65 List 15	A	...	...	...	...	...	...	...	11	$11\frac{1}{4}$	$11\frac{1}{2}$	$12\frac{5}{16}$	$12\frac{3}{8}$
	Q	...	...	...	...	...	...	...	20	22	24	26	31

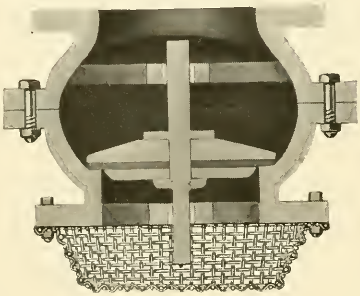


The Stem line always passes between two holes

THE LUDLOW VALVE MFG. CO.

Continued from preceding page

FOOT VALVES—CHECK VALVES—BLOW-OFF VALVES



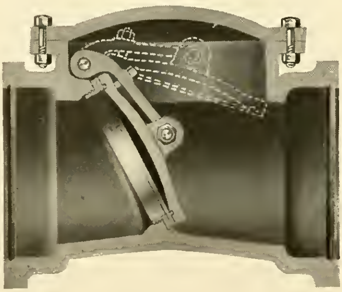
VERTICAL FOOT VALVES

Pages 96-97, 1910 Catalogue. Sizes 2″ to 36″. Iron Body. Rubber Faced Gate. Iron Seat Plate.

Sizes 9″ and under made like illustration.

Sizes 10″ and above made with nest of gates hand holes, and flat screen.

Flanged, screwed or hub ends.



HORIZONTAL SWING CHECK VALVES

Iron Body. Bronze Mounted. Sizes 2″ to 48″.

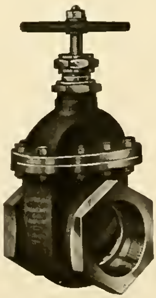
Patterns for 300 lbs. and 600 lbs. test.

14″ and above have By-pass.

18″ and above have relief gate.

30″ and above multiple type.

Flanged, screwed or hub ends.



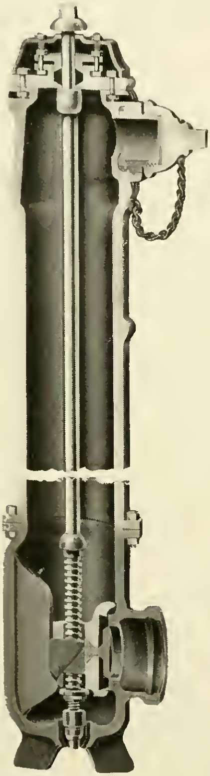
LUDLOW SPECIAL BLOW-OFF VALVES

Iron Body. Bronze Mounted.

Made with Hardened Iron gate faces and Hardened Iron removable seat rings.

Designed particularly for Boiler Blow-off. Gives excellent service.

THE LUDLOW VALVE MFG. CO.



FIRE HYDRANTS

Genuine Ludlow Slide Gate, Frost Proof, Fire Hydrant. Rubber-faced Gate. Bronze Mounted.

(a) Simple in construction.

(b) Drip valve in extreme bottom of hydrant, draining hydrant barrel completely and permitting no water to remain in same.

(c) All working parts can be removed without disturbing hydrant barrel or doing any digging.

(d) Gate is released from seat before starting to rise, avoiding wear on gate rubber.

(e) Gate when shut remains tight when top of hydrant is removed.

(f) No flooding of street in case standpipe or barrel is broken.

(g) In opening hydrant, first turn of the stem closes the drip valve, after which the bronze wedge nut in back of gate is loosened, relieving gate from its seat.

Final turn of the stem after gate is closed and wedged opens the drip valve.

(h) Frost case unnecessary.

(i) Large waterway.

From Page 110 Ludlow Catalogue, 1910

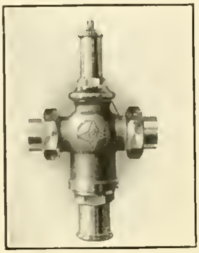
Size of Hydrant or Diameter Valve Opening............................	2″	3″	4″	4½″	5″	6″	8″
Inside diam. of Stand Pipe...........	3″	4⅝″	5¾″	6¼″	7″	8″	10″
Size Bottom Connections.............	2″	3″ or 4″	4″ or 6″	6″	6″ or 8″	6″ or 8″	8″ or 10″
Number and Size Nozzle............	1-2″	1-2½″	2-2½″	3-2½″	3-2½″	4-2½″	6-2½″

Steamer nozzles can be added on size 4″ and up, or can be substituted for 2½″ nozzle. Inside independent cut-off gate can be furnished on 2½″ nozzle if wanted.

THE MASON REGULATOR CO.

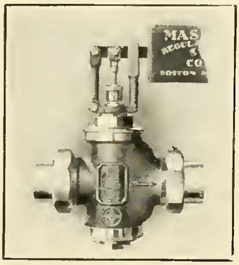
BOSTON, MASS.

REGULATING APPLIANCES FOR STEAM, WATER OR AIR. A partial list of our product is given below. For a more complete and detailed description of the following and of many other devices, see our general catalog.



MASON ALL-BRONZE REDUCING VALVES

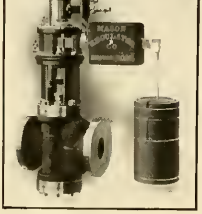
The Mason Standard Reducing Valve reduces and maintains even pressure of steam or air regardless of the variation of the initial pressure or of the volume of steam or air required. It automatically reduces boiler pressure for steam heating systems of all types (vacuum systems included), central heating plants, engines, paper machines, slashers, dye kettle and all situations where it is desirable to use a lower pressure than that on the boiler.



MASON ALL-BRONZE BALANCED VALVES

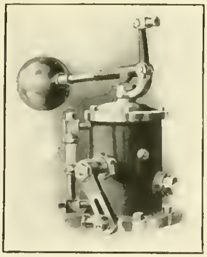
Mason All-Bronze, Balanced Valves with Yoke and Lever, are used to control pumps, engines, and the like, by means of tank floats or cords to distant points, and also in connection with various devices for controlling the flow to water wheels, receivers, open heaters, and other similar devices. They can be relied upon in any situation requiring a valve to be operated with a minimum amount of power.

MASON STEAM PUMP PRESSURE REGULATOR FOR HYDRAULIC ELEVATOR SERVICE



The Mason Steam Pump Pressure Regulator for Hydraulic Elevator Service was designed to meet the requirements of the larger sizes of steam pumps operating hydraulic elevators. The important features of this regulator are its extreme sensitiveness and quick action, as it completely opens or closes the steam valve with the slightest variation of pressure.

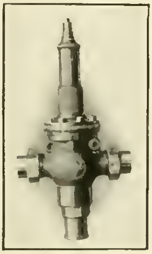
The Mason Steam Pump Pressure Regulator for Hydraulic Elevator Service has been extensively used during the past fifteen years for controlling steam pumps operating hydraulic elevators, thousands of them being in use and giving entire satisfaction.



MASON STEAM PUMP SPEED GOVERNOR

The Mason Steam Pump Speed Governor is to the direct-acting steam pump what the ordinary ball governor is to the steam engine. It derives its motion from some reciprocating part of the pump and controls a balanced valve placed in the steam pipe, thereby exactly regulating the amount of steam to the requirements of the pump, and automatically maintaining a uniform speed, regardless of any variation of steam or load.

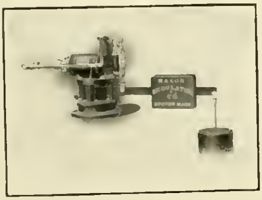
MASON STEAM PUMP PRESSURE REGULATOR



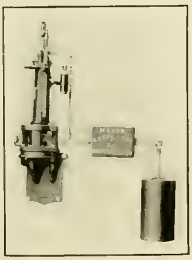
The Mason Steam Pump Pressure Regulator is designed for fire, boiler feed, air, and water works pumps, having steam supply pipe 4″ or smaller, or any class of pumping machinery where it is necessary to maintain a constant pressure.

The regulator is entirely self-contained. It is placed in the steam supply pipe to the pump and connected by ¼″ pipe to the discharge system, thereby exactly regulating the amount of steam to the requirements of the pump and automatically maintaining a uniform discharge pressure, regardless of any variation of steam pressure or demand on the pump. The regulator is provided with a dashpot, which positively prevents the pump from jumping under sudden changes of discharge pressure.

MASON HORIZONTAL PRESSURE-CONTROLLING DEVICE



The Mason Horizontal Pressure-Controlling Device, in its various modifications, is used for controlling power and electrically driven pumps of all types and on all classes of service, including vacuum systems. This device can be supplied with various sizes of diaphragms for vacuums, low pressures, and pressures up to 400 lbs., and with cup leather packed plungers for higher pressures up to 3000 lbs.



MASON HYDRAULIC DAMPER REGULATOR

The Mason belongs to that class of Regulators which are controlled by the variation of the boiler pressure, the motive power for opening or closing the damper being the water pressure, which can either be taken from the street main or from the boiler itself. A compensating arrangement is provided which prevents the Regulator from completely opening and closing the damper at each slight change of pressure.

JEFFERSON UNION COMPANY

LEXINGTON, MASS.

UNIONS AND FLANGES FOR OIL, STEAM, WATER AND GAS UNDER ALL PRESSURES. Malleable iron only is used for standard goods and brass tubing for rings for seats.

Three Part — STYLE B FLANGE (Fig. 3)

Pipe Size	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$
Outside Diameter	$2\frac{7}{8}$	$3\frac{5}{32}$	$3\frac{3}{4}$	$4\frac{3}{16}$	$4\frac{1}{2}$	$5\frac{9}{16}$	$6\frac{3}{16}$	$6\frac{13}{16}$	$7\frac{11}{16}$
Length Over all	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{21}{32}$	$2\frac{15}{16}$	$3\frac{3}{16}$	$3\frac{7}{16}$	$3\frac{11}{16}$	$3\frac{16}{16}$	$4\frac{1}{4}$

Pipe Size	4	$4\frac{1}{2}$	5	6	7	8	9	10
Outside Diameter	9	$9\frac{9}{16}$	$10\frac{1}{16}$	$11\frac{3}{8}$	$12\frac{7}{16}$	14	15	$16\frac{1}{4}$
Length Over all	$4\frac{1}{2}$	$4\frac{5}{8}$	$4\frac{13}{16}$	$4\frac{15}{16}$	$5\frac{3}{16}$	$5\frac{5}{16}$	$5\frac{9}{16}$	$5\frac{27}{32}$

Two Part — STYLE D FLANGE

Pipe Size	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$
Outside Diameter	$2\frac{7}{8}$	$3\frac{11}{32}$	$3\frac{11}{16}$	$4\frac{1}{8}$	5	$5\frac{21}{32}$	$6\frac{1}{4}$	7	$7\frac{5}{8}$
Length Over all	$2\frac{5}{16}$	$2\frac{7}{16}$	$2\frac{21}{32}$	$2\frac{26}{32}$	$2\frac{31}{32}$	$3\frac{1}{32}$	$4\frac{1}{6}$	$4\frac{5}{16}$	$4\frac{15}{32}$

Pipe Size	4	$4\frac{1}{2}$	5	6	7	8	9	10	12
Outside Diameter	$8\frac{3}{4}$	$9\frac{5}{16}$	10	$11\frac{7}{32}$	$12\frac{11}{32}$	$13\frac{31}{32}$	$15\frac{1}{16}$	$16\frac{9}{32}$	$18\frac{3}{8}$
Length Over all	$4\frac{19}{32}$	$4\frac{23}{32}$	$4\frac{27}{32}$	$5\frac{3}{32}$	$5\frac{11}{32}$	$5\frac{19}{32}$	$5\frac{27}{32}$	$6\frac{5}{32}$	$6\frac{21}{32}$

STYLE E FLANGE (Fig. 4)

Two Part—Extra Heavy

Pipe Size	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
Outside Diameter	$4\frac{1}{8}$	$4\frac{9}{16}$	$5\frac{3}{16}$	6	$6\frac{31}{32}$	$7\frac{3}{4}$	$8\frac{3}{8}$	$9\frac{17}{32}$
Length Over all	$3\frac{17}{32}$	$3\frac{25}{32}$	$4\frac{1}{32}$	$3\frac{23}{32}$	$4\frac{3}{4}$	$4\frac{15}{16}$	$5\frac{3}{32}$	$5\frac{7}{32}$

Pipe Size	$4\frac{1}{2}$	5	6	7	8	9	10
Outside Diameter	$10\frac{5}{32}$	$10\frac{27}{32}$	$12\frac{1}{8}$	$13\frac{13}{16}$	$14\frac{31}{32}$	$16\frac{3}{32}$	$17\frac{6}{16}$
Length Over all	$5\frac{11}{32}$	$5\frac{17}{32}$	$5\frac{27}{32}$	$6\frac{5}{32}$	$6\frac{13}{32}$	$6\frac{23}{32}$	$7\frac{1}{32}$

Jefferson Style A Unions (Fig. 2) are made with spherical brass to iron seats ground to a perfect fit. The ring *A* is of wrought metal, cut from seamless brass tubing, avoiding blowholes common in cast brass. There are special advantages in the use of the brass ring in just the manner shown and the wall *B* is patented owing to these advantages, which include protecting the brass from injury no matter how far the pipe is screwed in. No gasket is used and there is plenty of play for the part *F* which swivels in the nut. Dimensions are given in following table.

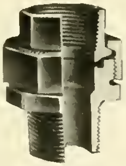


Fig. 1

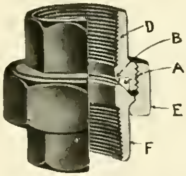


Fig. 2

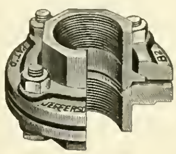


Fig. 3

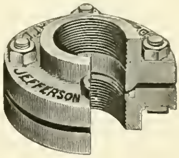


Fig. 4

STYLE A UNION

"Standard Type" All Female

Pipe Size	1/8	1/4	3/8	1/2	3/4	1	1 1/4
Diameter Nut (Across Flats)................	1 3/16	1 13/32	1 37/64	1 13/16	2 1/8	2 33/64	3
Length Over all..............................	1 33/64	1 45/64	1 57/64	2 3/32	2 9/32	2 1/2	2 3/4

Pipe Size	1 1/2	2	2 1/2	3	3 1/2	4
Diameter Nut (Across Flats).................	3 13/32	4 7/32	4 59/64	5 23/32	6 9/16	7 27/64
Length Over all..............................	3	3 7/16	3 29/32	4 11/32	4 11/16	4 63/64

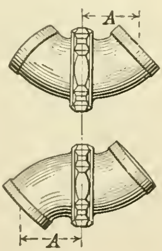
The Jefferson Style F Union (Fig. 1) is short and more easy to use than the union and nipple which it replaces. It has Briggs Std. pipe threads. Any kind of wrench may be used on any of its parts.

STYLE F UNION

Male and Female

Pipe Size	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
Diameter Nut (Across Flats)...	1 13/32	1 37/64	1 13/16	2 1/8	2 33/64	3	3 13/32	4 7/32	4 59/64	5 23/32
Length Over all	2 5/32	2 11/32	2 11/16	2 57/64	3 17/64	3 17/32	3 3/4	4 13/64	5 1/8	5 35/64

SWING UNION



Pipe Size	1/8	1/4	3/8	1/2	3/4
Diam. Nut (Across Flats)...............	1 3/16	1 7/16	1 41/64	1 29/32	2 1/4
Length A...............................	1 11/64	1 23/64	1 31/64	1 11/16	1 55/64

Pipe Size	1	1 1/4	1 1/2	2	2 1/2
Diam. Nut (Across Flats)	2 43/64	3 7/32	3 21/32	4 17/32	5 21/64
Length A................................	2 9/64	2 3/8	2 37/64	2 63/64	3 5/8

BARCO BRASS & JOINT CO.

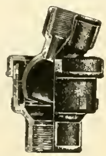
226-230 N. JEFFERSON ST., CHICAGO, ILL.

THE BARCO FLEXIBLE BALL JOINT (MARTINS PATENT)
FOR STEAM, AIR, GAS, OIL, OR OTHER LIQUIDS.

BARCO FLEXIBLE JOINTS

The ball, sizes up to 6″, is surrounded by non-metallic gaskets, which prevent metal-to-metal contact, take up the wear and are reversable and renewable. They are hard, extremely durable and will not disentegrate under high pressures, extreme heat, or by coming in contact with liquids.

Sizes above 6″ are equipped with the Barco patent packing device which makes the joint absolutely tight both under pressure or suction. By this method, the packing can be kept in place, or the joint repacked without disconnecting from pipe or removing the casing or ball.



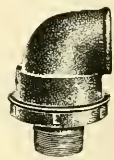
PAT. JAN. 6, 1903
STRAIGHT JOINT FEMALE ENDS
Sectional View

The Barco Joints are made as below:

In brass from $\frac{1}{4}$ to $2\frac{1}{2}$″ either straight or angle and with male or female ends.

In malleable iron from $\frac{1}{4}$ to 3″ and cast iron 4 to 6″ straight or angle with female ends only, unless otherwise ordered.

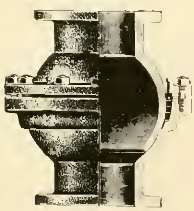
With flange, or hub and spigot ends from 4 to 36″ in cast iron, semi-steel, steel, or manganese steel lined. The angle of movement ranges from 16 to 30 degrees on each side of the center line, or 360 degrees of movement if used as a swivel.



PAT. JAN. 6, 1903
90° ANGLE JOINT

DIMENSIONS OF THE BARCO FLEXIBLE JOINTS

For Steam, Air, Gas and Liquids



PAT. OCT 6, 1908
THE BARCO FLEXIBLE JOINTS
With Flange Ends

With Flange Ends			With Hub and Spigot Ends		
Size	Diameter of Flanges	Length Face to Face	Size	Laying Length-Hub and Spigot	Laying Length-Hubs Both Ends
4	9 in.	11 in.	4	$17\frac{7}{8}$ in.	$10\frac{3}{4}$ in.
5	10 in.	$12\frac{1}{2}$ in.	6	$17\frac{7}{8}$ in.	$12\frac{3}{4}$ in.
6	11 in.	$13\frac{3}{4}$ in.	8	24 in.	$17\frac{1}{4}$ in.
8	$13\frac{1}{2}$ in.	$20\frac{7}{8}$ in.	10	26 in.	18 in.
10	16 in.	22 in.	12	$25\frac{1}{4}$ in.	$18\frac{1}{4}$ in.
12	19 in.	22 in.	14	$27\frac{1}{2}$ in.	20 in.
14	21 in.	24 in.	16	28 in.	22 in.
16	$23\frac{1}{2}$ in.	$28\frac{1}{4}$ in.	18	33 in.	26 in.
18	25 in.	30 in.	20	$35\frac{3}{4}$ in.	$28\frac{1}{4}$ in.
20	$27\frac{1}{2}$ in.	32 in.	24	36 in.	30 in.
24	32 in.	36 in.	30	38 in.	$32\frac{1}{2}$ in.
30	38 in.	$42\frac{3}{4}$ in.	36		
36	$45\frac{3}{4}$ in.	$41\frac{1}{2}$ in.			

These joints are made to meet the most exacting requirements of engineers and contractors for laying pipe lines under water, over rough country and where peculiar angles or bends are required. They may also be used where expansion or contraction must be provided for.

THE ALBANY STEAM TRAP CO.

317-319 No. PEARL ST., ALBANY, N. Y.

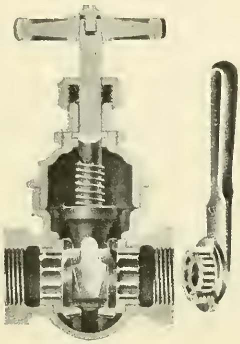
STEAM TRAPS, PUMP GOVERNORS, SEPARATORS, VALVES AND UNIONS

IMPROVED RETURN BUCKET TRAPS—Class A. Returns the water of condensation from jacketed cylinders, kettles, dry-rooms, heating systems, etc., directly into the boiler without the aid of steam pumps or like devices. Good up to 250 lb. pressure.

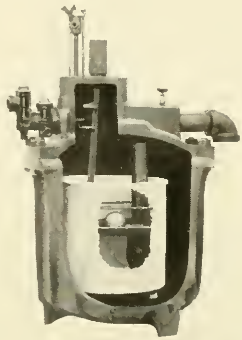
NON-RETURN TRAPS—Class B. For pressures up to 250 lb.

Class C. For pressures up to 100 lb. No. 6 special double-seated discharge valve, permitting rapid discharge of large quantities of water under low pressure.

Class D. For pressures up to 250 lb. where superheating is employed.



Gate Valve



Return Steam Trap

TABLE OF CAPACITIES AND DIMENSIONS OF TRAPS

Sizes	Capacity, Gal. per Min.	Inlet	Outlet	Height, In.	Sizes	Capacity, Gal. per Min.	Inlet	Outlet	Height, In.
	Class "A"					Class "C"			
A-2	15 to 25	2	2½		1	½	½	½	12
A-1	10 to 15	1½	2	43	2	¾	¾	¾	14½
1	4 to 8	1½	2	33	3	1¼	1	1	17½
2	3 to 6	1	1½	30	4	2	1¼	1¼	20
0	½ to 1	½	1	22	5	4	1½	1½	23
					6	10	2	2	27½
	Class "D"					Class "B"			
2	12 to 18	2	2	28					
1	6 to 10	1½	1½	25	1	6 to 10	1½	1	23
00	4 to 8	1	1	22½	2	12 to 18	2	1½	28

VALVES—Globe, Check, Gate and Angle with seats and discs renewable without removing body of valve from line of pipes. For 250 lb. steam pressure.

SEPARATORS—Duplex Horizontal for water and oil.

PUMP AND GOVERNOR—Is for returning condensation to boiler, where the use of the return trap is not practical.

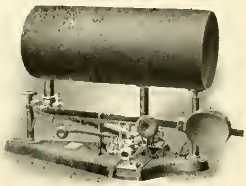
PUMP GOVERNORS—For use with other steam pumps sold independently.

MOREHEAD MFG. CO.

DETROIT, MICH.

TILTING STEAM TRAPS, RETURN, NON-RETURN, VACUUM AND CONDENSER TYPES, FOR DRAINING HIGH OR LOW PRESSURE AND VACUUM HEATING SYSTEMS OF WATER OF CONDENSATION, and where desired, returning the condensation to the boiler as feed water. There is a Morehead Steam Trap to meet every condition arising in a steam or gas plant.

RETURN STEAM TRAP



Morehead Return Steam Trap

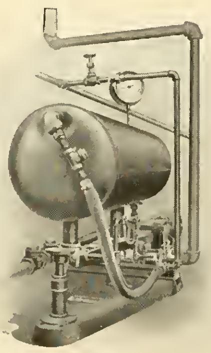
The Return Steam Trap removes water of condensation from heating, drying and cooking apparatus and returns the condensation direct to the boilers regardless of any difference in pressure on the apparatus drained and the boiler or whether the apparatus is located above or below the water line. It is admirably adapted for use as a lift pump and for feeding boilers from open or closed heaters. It handles perfectly, water at any temperature

NON-RETURN TRAP

Morehead Non-Return Steam Trap

This type of Morehead Steam Trap is especially adapted to the removal of condensation from high or low pressure steam mains, dryers, heaters, etc., and delivering the water to an open tank, hot well or feed water heater. This trap has a removable seat and disc in the valve. It discharges from low point, insuring an effective *water seal* at all times. It is guaranteed for 200 lbs. working pressure.

VACUUM TRAP



Morehead Condenser Trap

This is a cut of an actual installation. The check valves and gage shown in cut are only furnished as extras.

The Vacuum Trap removes automatically all condensation from exhaust lines and oil separators operating under a vacuum without breaking or impairing that vacuum. It delivers the water of condensation to any desired point above or below the location of the trap and is guaranteed not to effect the vacuum in in any way.

CONDENSER TRAP

The Condenser Trap is a combination of the features of a Morehead Automatic Return Trap and the Jet or Spray Condenser. It is especially adapted to service on exhaust steam and reduced pressure heating, cooking and drying apparatus. The *positive vacuum* formed in the tank of the trap removes rapidly all condensation in the system, accelerates the travel of the steam and reduces the back pressure on the engine.

MOREHEAD TILTING NON-RETURN STEAM TRAPS

Sizes and Capacities

No.	Inlet Inches	Outlet Inches	Capacity in Water Discharged per Hour	Drainage Capacity in 1 inch Pipe Lineal	Capacity Square Feet Direct Radiation	Capacity Lineal Feet Hot Blast Heater	Weight
21	1	1	200 gal.	12000 ft.	3000	1300	100
22	1¼	1¼	400 "	25000 "	5200	2400	175
23	1½	1½	600 "	40000 "	12000	5200	250
24	2	2	720 "	60000 "	21000	9000	275
25	2½	2½	900 "	90000 "	33000	16000	350
26	3	3	1300 "	140000 "	50000	25000	450

MOREHEAD TILTING RETURN AND VACUUM STEAM TRAPS

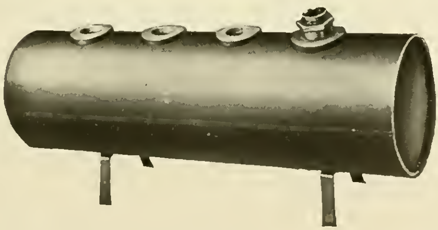
Sizes and Capacities

No.	Size of Drum	Size of Inlet and Outlet Connections Inches	Size of Steam Pipe Connections Inches	Capacity of Water in Lbs. per Hour	Drainage Capacity in feet of 1 inch Pipe Lineal	Capacity Square Feet Direct Radiation	Capacity Lineal Feet Hot Blast Heater	Weight
1	10 x 24	1	1	1050	5000	2300	1000	100
2	12 x 30	1¼	1	1850	9000	4000	1800	175
3	14 x 36	1½	1¼	4000	20000	9000	4000	250
4	16 x 40	2	1¼	6000	35000	16000	7000	275
5	18 x 42	2½	2	11000	50000	25000	12000	350
6	18 x 42	3	2	15000	75000	40000	18000	400

The above capacities are figured on a basis of 50 pounds pressure to the square inch. The above drainage capacity in inch pipe is based on ordinary radiating conditions. For lumber kilns, greenhouses and moist goods, divide by two. For laundries, brick dryers and wet goods, divide by three. For fan stacks and blowers, divide by five.

NOTE—3 feet of 1 inch pipe equals one square foot of surface. 2.3 feet of 1¼ inch pipe equals one square foot of surface. 2 feet of 1½ inch pipe equals one square foot of surface. 1.61 feet of two inch pipe equals one square foot of surface.

MOREHEAD RECEIVERS



No.	Length Inches	Height Inches	Diameter Inches
1	30	16	10
2	40	20	12

No. 1 Receiver has capacity for Traps Nos. 1 and 2. No. 2 Receiver has capacity for Traps Nos. 3, 4, 5 and 6.

We will be glad to advise regarding the installation of traps to meet the conditions of your steam system.

THE OHIO INJECTOR COMPANY

WADSWORTH, OHIO

GARFIELD AND CHICAGO INJECTORS; GARFIELD DOUBLE JET INJECTOR; CHICAGO AUTOMATIC INJECTOR; CHICAGO DOUBLE CONNECTION LUBRICATOR; "O. I. CO." GLOBE, ANGLE AND SWING CHECK VALVES; OIL AND GREASE CUPS; WATER GAUGES AND GAUGE COCKS, ETC.

THE CHICAGO AUTOMATIC INJECTOR

This injector is very simple, consisting of but three tubes, the body or shell, one check valve and a bushing. All these parts are held in place by screw threaded joints and cannot drop out and become lost. Fig. 1 shows the standard type. This Injector will start low from 15 to 20 pounds steam pressure on 4 ft. lift. Will work high to 155 to 165 lb. steam pressure. Will work on a 20 to 22 ft. lift with 60 to 90 lb. steam pressure. Will grade 50 per cent. That is, its capacity may be reduced one half before it will stop working. Will work water 120 to 125 degrees hot. Will work when taking water from a lift or under pressure.

THE GARFIELD DOUBLE JET INJECTOR

This injector is designed especially for use on stationary boilers. It has no movable parts, requires no adjustment for varying steam pressures and contains very few parts to look after.

Figure 2 shows the Standard Type of The Garfield Double Jet Injector. It will work at all pressures from 20 to 200 lb. and over, and will start and lift water at normal temperature, as follows: 4 ft. lift on 15 to 20 lb. steam. 15 ft. on 15 to 40 lb. steam, 25 ft. on 15 to 60 lb. steam. It will handle hot water supply about as follows with lift of 4 ft. or less. 140 degrees at 60 to 80 lb. steam, 130 degrees at 60 to 100 lb. steam, 100 degrees at 60 to 150 lb. of steam. Above 90 lb. steam, lift decreases as steam pressure increases.

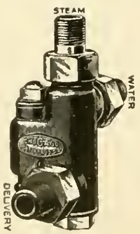


Fig. 1

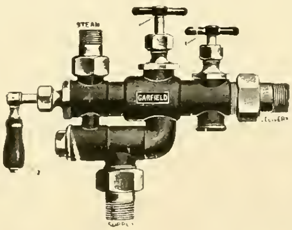


Fig. 2

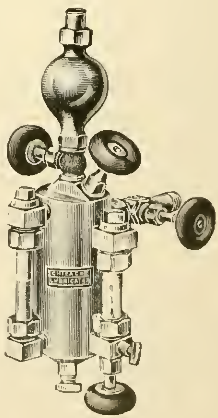


Fig. 5

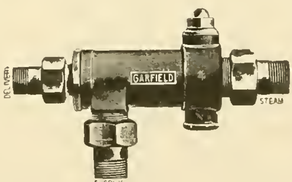


Fig. 3

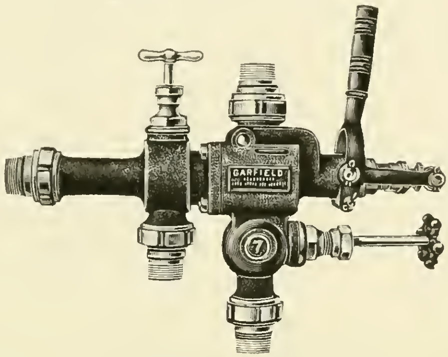
Fig. 4

Fig. 1—The Chicago Automatic Injector.
Fig. 2—The Garfield Double Jet Injector.
Fig. 3—The Garfield Automatic Injector.
Fig. 4—The Garfield Injector.
Fig. 5—The Chicago Double Connection Sight Feed Lubricator.

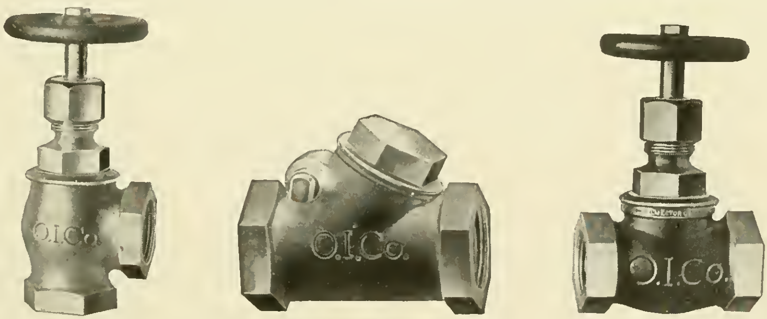
THE OHIO INJECTOR COMPANY

THE GARFIELD LOCOMOTIVE INJECTOR

This injector cannot be excelled for marine and stationary use. It is constructed in two sections and can be taken apart readily with an ordinary wrench and access secured to all parts. Should the water supply be interrupted from any cause, it will instantly re-start itself as soon as interruption is removed. Range 35 to 200 lb. steam.



THE O. I. CO. GLOBE, ANGLE AND SWING CHECK VALVES



New valves suitable in every way for service under the exacting conditions now existing in steam engineering and yet not excessive in price.

The disc is made of special nickle bronze which by a long series of tests we have found to be best suited to withstand the action of high pressure steam and the mechanical wear to which these parts are subjected.

All other parts of the valves, except the wheel, are made of the same high grade steam metal which we use in the manufacture of our locomotive steam appliances; a composition composed entirely of new metal.

All parts are made to gauge, thus insuring perfect fits in pipe threads and perfect interchangeability. The hexagons on body, bonnet and packing nut are not ground, but milled, thus affording a close fit with wrench jaws.

Our valves may be packed while under pressure by screwing the stem back as far as possible. For packing we use a special moulded split ring which requires very little compression to hold steam tight.

The areas in our valves are extremely liberal and far in excess of the pipe areas.

Guaranteed for 200 lb. steam pressure. Tested by hydraulic pressure far in excess of this.

POWER SPECIALTY COMPANY

111 BROADWAY, NEW YORK, N. Y.

Boston Philadelphia Chicago Pittsburg San Francisco

FOSTER SUPERHEATERS; DUVAL METALLIC PACKING; SUPERHEATED STEAM BRONZE GASKETS, HEENAN MUNICIPAL REFUSE DESTRUCTORS.

FOSTER SUPERHEATERS

The Foster Superheater is made in four general types, as follows:

Attached Type for Superheating up to 200 deg. Fahr.

Separately-Fired Type for any variety of fuel and any range of superheat up to 1200 deg. Fahr.

Waste-Heat Type for steel and fabric mills or marine practice.

Portable Type for heating steam or air with oil, coal or gas fires.

Great strength and durability, combined with extreme simplicity and adaptability to any type of boiler.

Structural Features

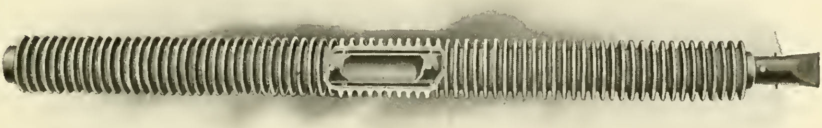
Steam is superheated while being passed in parallel through straight elements of our standard composite construction exposed to the action of the hot furnace gases.

The elements are expanded at one end into steel manifold headers and are provided at the free ends with jointless return bends or are expanded into individual steel return headers.

Opposite the end of each element a handhole fitted with steel plug and metallic gasket is provided to give free access to every part of the interior for inspection or cleaning. All holes into which tubes are expanded or handhole plugs fitted are carefully reamed to gage.

2″ Handhole plug, gasket, cap and nut used in construction of Foster Superheaters

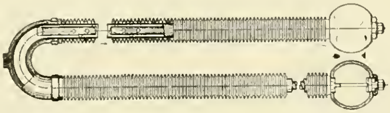
The elements consist of bodies of seamless cold-drawn steel tubing, to the outside of which is snugly fitted a heat-resisting cast-iron covering with deep external annular corrugations for the protection of the bodies against the action of the heated gases. These annular gill flanges form an extension surface for the absorption of heat from the hot gases, which heat is passed to the steam contained in the tubes. They provide a section of great ultimate strength with absolute freedom from internal strains. They also provide a mass of metal which acts as a reservoir for heat to be imparted to the steam regularly and prevent fluctuations in the temperatures of the hot gases from producing corresponding fluctuations in the superheating of the steam. An inner tube or core is fitted to each straight heating tube, the core being of cylindrical form closed at each end and supported concentrically with the tube by frequently spaced steel knobs. This thin annular conduit for the passage of the steam while receiving the superheat adds greatly to the efficiency of the heating surface and avoids the storage of a large quantity of steam and superheat.



SUPERHEATED STEAM

Superheating steam has become a modern necessity; saving fuel, increasing capacity and duty of engines and turbines, insuring longer life and greater economies in boiler, steam pipe and condenser.

For steam turbines, reciprocating engines, generating units, feed pumps and auxiliaries, any superheat up to 500 deg. Fahr. will be found satisfactory. For industrial uses, temperatures up to 1200 deg. Fahr. are made possible by the Foster construction.



Cross section of return bend element and connecting headers used in the construction of Foster Superheaters

DUVAL METALLIC PACKING

is extensively used for superheated and saturated steam, also for steel or iron plungers where working in water or oil, in pumps or accumulators, for heavy pressures from 500 to 2500 pounds per square inch of pressure. No special stuffing-box is required. The packing is flexible, made of fine quality wire plaited in square form and is easily cut with wood chisel. It is adopted in the French, British and American Navies.

SUPERHEATED STEAM BRONZE GASKETS

give excellent satisfaction for flanged joints carrying superheated steam. The metal has elastic properties and the corrugations are even, with sharp ridges.

SCHUCHARDT & SCHUTTE

21-23 ALBANY STREET, NEW YORK

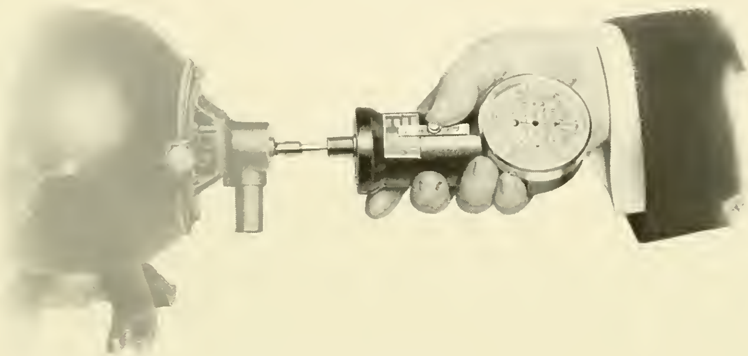
S. & S. TACHOMETERS AND TACHOGRAPHS, PORTABLE AND STATIONARY, MADE FOR ALL PURPOSES AND REQUIREMENTS.

S. & S. TACHOMETERS

The scales can be divided for any desired reading, such as revolutions, periods, feet, yards, inches or other units, at any desired rate of time.

S. & S. TACHOMETERS cannot be damaged if used on the wrong speed range.

Heat, dampness and magnetism have no influence on the absolute accuracy of these tachometers.



No. 4 Hand Tachometer.

Any right or left hand speed is directly recorded on the dial without calculation and irrespective of the duration of the test. No watch is required.

There is only one spindle for four speed ranges, adjustment for the proper speed range being obtained by simply shifting a thumb slide, while the object under test is running.

Speed Ranges of Hand Tachometers

#4 ..	30–120,	100–400,	300–1200,	1000–4000
#5 ..	60–240,	200–800,	600–2400,	2000–8000
#6 ..	100–400,	300–1200,	1000–4000,	3000–12000

"INITIATIVE" REVOLUTION COUNTERS

will record right or left-hand revolutions from 0 to 10000 and will then repeat. They give the count in the form of an ordinary number and permit being set back to zero from any number.

A. WYCKOFF & SON CO.

ELMIRA, NEW YORK

MANUFACTURERS OF PATENT WATERPROOF PIPE COVERINGS FOR STEAM

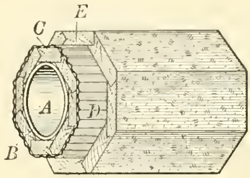


FIG. 1
Lined for pressures over 5 lb.

A=Tin Lining
B=Asbestos
C=Wood
D=Corrugated Paper
E=Wood

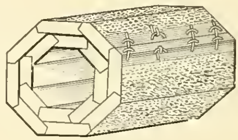


FIG. 2
Unlined for pressures below 5 lb.

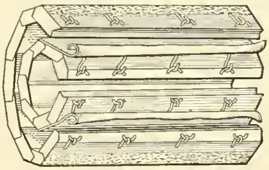


FIG. 3

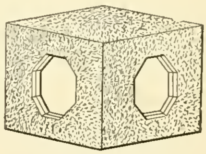


FIG. 4

This covering is constructed of eight thoroughly seasoned white pine staves one inch thick closely jointed together, wound with heavy galvanized iron wire and then wrapped with two layers of heavy corrugated paper. It is finished by having another casing of white pine jointed staves outside of the inner casing, making two casings of wood each one inch thick with a non-conducting lining of corrugated paper between. A thin air chamber between each layer of wood and paper adds to non-conducting qualities.

For underground use the covering is coated with Asphaltum Pitch.

For overhead use the covering is painted outside with Asphaltum Paint.

Lengths 4 to 8 feet, sections meet with tenon and socket joints. Drive together. Details of covering shown in Figs 1–2–3 and 4.

Fig. 1 shows our high-pressure Patent Tin and Asbestos Lined Covering made up to slip over the pipes as they are being installed. The tin is placed inside the covering to intensify the heat radiation and keep a more uniformly high temperature in the line.

Fig. 2 shows our Unlined Patent Covering manufactured to slip over the pipe as it is being installed but where the steam preasure is not more than 5 lb.

Fig. 3 shows our Patent Covering Unlined, opened to apply on pipes already in place. We can open the Lined as well as the Unlined Covering.

Fig. 4 illustrates the manner of covering tees and elbows. The top is put on with screws so that it can be easily and quickly removed whenever necessary.

AMERICAN HUHN METALLIC PACKING CO.

410-416 EAST 32d STREET, NEW YORK CITY

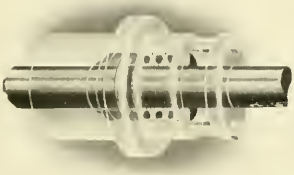
SELF-LUBRICATING METALLIC PACKING for steam, water, gas, air, CO_2, aqueous and gaseous ammonia, H_2SO_4, brine, oil, varnish, etc., for extreme conditions of service and the highest pressures. Estimates furnished for complete plant equipment of packings and contracts made for their installation and maintenance through any period of years on a guarantee basis.

TYPE XXII : STEAM

A flexible, elastic, continuously lubricating packing, contained in a simplified cage design. Three years guarantee. For vibrating or unlined rods. Adjustment for play can be made to any degree.

As the particular function of the graphite is to re-coat the surfaces, removing all possibility of metallic contact, it will be found that extremely thin oils will supply all the "additional" lubrication necessary.

TYPE XII: H.P. AIR (AND WATER) 500-1000 LB.

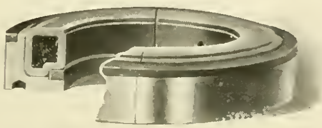


All-metal (gasket interspaced) self-lubricating, two-section, indented-ring Standard Type XII, designed to the full size and depth of the stuffing-box. Babbitt composition. No alterations. Guarantee varies.

Graphite, being an inert mineral, is unaffected by any degree of heat possible in an air compressor cylinder, so that under no conditions will it volatilize, carbonize, or bake into a form interfering with free valve action.

By combining a (metallic) packing and (graphite) lubrication system in one, immediate provision is made against the "burning out" of the rings, a lubricant is provided totally unaffected by the extremes of temperature, and a packing product is developed on which a stated definite guarantee can be given.

FOR GASEOUS AMMONIA—SINGLE AND DOUBLE ACTING COMPRESSORS.



All metal (gasket interspaced) self-lubricating, two section, indented ring, Standard Type XXI, designed to the full size and depth of the stuffing-box.

Babbitt composition. Three years guarantee. No alterations necessary.

Lanterns as with fibrous packing.

In HUHN, the solid construction of the packing forms an effectual ammonia seal on the rod and against the stuffing box wall, the intermediary gasket compensates for the expansion and contraction of the rod and packing during ordinary operation and the gasket placed at the head of the rings fulfills a two-fold purpose: (a) as an oil seal, and (b) as anauxiliary expansion ring. Three year guarantee on new or renewed equipment.

SPECIALS

The requirements will be carefully considered, and if a successful design can be constructed, proposals will be made under a stated guarantee. It should be remembered in this connection that pressure, vacuum, temperature and speed have no direct influence on HUHN, the main consideration lying in its adaptation to the stuffing-box and the demands of operation under the given conditions.

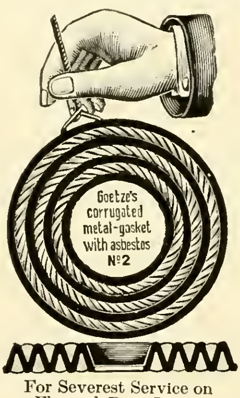
AMERICAN GOETZE-GASKET AND PACKING CO.

NEW BRUNSWICK, N. J.

COPPER AND METAL GASKETS. METALLIC ENGINE PACKING. SHEET PACKING FOR FLANGES. COPPER VALVE GASKETS

GOETZE'S COPPER AND METAL GASKETS

are adapted to all apparatus requiring or making steam. The gaskets are manufactured in sizes up to and even over 7 ft., composed of chemically pure copper, as well as of any other desired material such as steel, lead, nickel, aluminum, brass, bronze, composition, etc. The line includes copper gaskets, corrugated gaskets of copper with asbestos lining, double copper gaskets with asbestos graphite between and asbestos lining, copper gaskets with graphite coating, profiled copper manhole gaskets with asbes-os-graphite and copper-asbestos gaskets.



For Severest Service on Flanged Pipe Joints.

Goetze's Elastic Corrugated Copper Gasket with Asbestos Lining No. 2, for flanges, makes a joint practically as leak-proof as the pipe itself, even with the roughest, most uneven surfaces.

It not only makes a *tight* joint, but a *permanently* tight joint, under *any pressure or temperature.* Numerous exacting tests, as well as severe trials in actual service, have shown that it is not affected by sudden and radical changes of temperature (from extremes of heat to extremes of cold, and vice versa).

Furthermore, instead of requiring frequent renewal, often involving great labor cost and expensive shut-downs, "Goetze's No. 2." lasts for years, and may be used over and over again.

Goetze's Seamless Copper Gaskets with Graphite Coating for Unions are very durable, give entire satisfaction and stand any pressure and superheated steam, oils, air, etc.

"GOETZERIT"

is a sheet packing for flanges made from pure, prime, asbestos fibre, compressed under an exceedingly high pressure and impregnated with a substance which makes it proof against the action of superheated and saturated steam, acids, ammonia, gas, alkaline products, etc. It is made in sheets approximately 39 inches by 39 inches of any desired thickness and ready-made gaskets for standard and extra-heavy flanged fittings of from one inch to 24 inches in diameter are kept in stock. Price in sheets $1.00 per lb.

GOETZE'S REX METALLIC ENGINE PACKING

is a small and practical packing for stuffing boxes working under pressures up to about 185 pounds per square inch and at temperatures about 428 degrees Fahr. The packing is supplied in the form of shavings and is composed of a special proved alloy impregnated with flaked graphite and cylinder oil. Price $1.50 per lb.

Goetze's Gaskets are a guarantee against frequent, costly shut-downs for packing renewals

Price List

For Standard Flanged Fittings				For Extra Heavy Flanged Fittings		
Price per Goetze's No. 2 Gasket	Price per Goetzerit Gasket	Size of Gaskets in. × outs. dia. inches	Size of Pipe inches	Size of Gaskets in. × outs. dia. inches	Price per Goetzerit Gasket	Price per Goetze No. 2 Gasket
$0.08	$0.04	⅝ x 1¼	½	⅝ x 2⅜	$0.05	$0.09
.12	.05	⅞ x 2	¾	⅞ x 2⅝	.06	.14
.16	.06	1¼ x 2½	1	1¼ x 2⅞	.08	.18
.20	.06	1½ x 2¾	1¼	1½ x 3⅛	.08	.27
.24	.08	1¾ x 3	1½	1¾ x 3½	.10	.30
.32	.11	2¼ x 4	2	2¼ x 4¼	.15	.36
.40	.15	2¾ x 4¾	2½	2¾ x 5	.19	.45
.48	.19	3¼ x 5¼	3	3¼ x 5⅞	.24	.54
.56	.25	3¾ x 6¼	3½	3¾ x 6½	.27	.63
.64	.28	4¼ x 6⅝	4	4¼ x 7	.33	.72
.72	.30	4¾ x 6⅞	4½	4¾ x 7⅝	.35	.81
.80	.33	5¼ x 7⅜	5	5¼ x 8⅜	.44	.90
96	.40	6¼ x 8⅝	6	6¼ x 9¾	.55	1.08
1.12	.50	7¼ x 9⅞	7	7¼ x 10⅞	.70	1.26
1.28	.63	8¼ x 10⅞	8	8¼ x 12	.75	1.44
1.44	70	9¼ x 12⅜	9	9¼ x 13	.85	1.62
1.60	.80	10¼ x 13¼	10	10¼ x 14¼	1.00	1.80
1.92	1.00	12¼ x 16	12	12¼ x 16¾	1.25	2.16
2.24	1.25	14½ x 17⅝	14	14½ x 19	1.65	2.52
2.40	1.45	15½ x 18⅞	15	15½ x 19⅞	1.80	2.70
2.56	1.75	16½ x 20⅛	16	16½ x 21⅜	2.10	2.88
2.88	1.90	18½ x 21½	18	18½ x 23⅝	2.40	3.24
3.20	2.10	20½ x 23¾	20	20½ x 25½	2.75	3.60
3.52	2.50	22½ x 25⅞	22	22½ x 27½	3.00	3.96
3.84	2.80	24½ x 28⅛	24	24½ x 30	3.50	4.32

GOETZE'S COPPER VALVE GASKETS

with an Inlay of Asbestos, insure longer life and gre^ater usefulness to new valves, and renew the life of old ones.

They are made for Jenkins' and similar valves—a clever combination of elastic copper asbestos, forming a cushion on which the seats may lose without injury to it or themselves, and with the certainty of closing tightly. In valves of the Jenkins type, there is no longer any excuse for leaks or for frequent renewals, for Goetze's Valve Gaskets have all the elacticity that's needed, yet cannot deteriorate and disintegrate like rubber.

Price List

Size of Valve	Price per Gasket	Size of Valve	Price per Gasket	Size of Valve	Price per Gasket	Size of Valve	Price per Gasket
¼ inch.	$0.10	1¼ inch	$0.23	3½ inch	$1.00	7 inch	$3.70
⅜ "	.10	1½ "	.30	4 "	1.40	8 "	4.00
½ "	.10	2 "	.35	4½ "	2.00	9 "	5.00
¾ "	.12	2½ "	.55	5 "	2.00	10 "	5.50
1 "	.16	3 "	.75	6 "	2.30	12 "	7.20

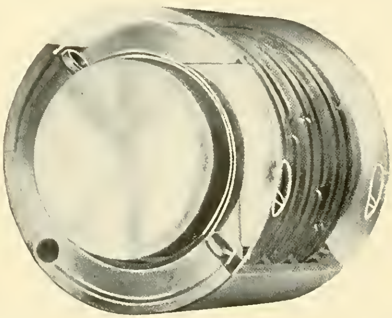
THE METALLIC PACKING & MFG. CO.

L. H. MARTELL, Mechanical Engineer & Gen'l Manager

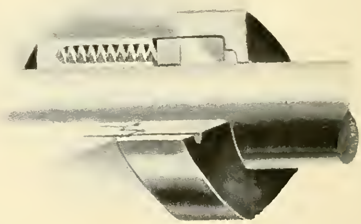
ELYRIA, OHIO

MAKERS OF MARTELL PACKING

We are Consulting Engineers on metal packing problems as well as manufacturers. Our product is not confined to one make or style, but is designed to meet the requirements of each application. We are constantly coöperating in this way with the most eminent designers and builders in the country.



For steam piston rods in ordinary size and service



For Corliss valve stems

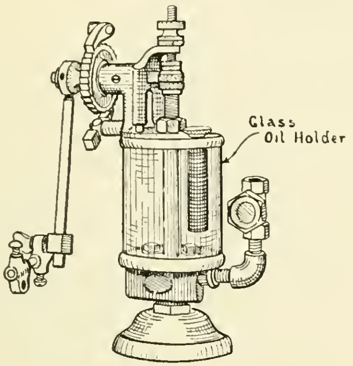
Martell Metal Packings successfully eliminate the excessive friction arising from the contact of moving metal and fibrous material and insure the continuous and economical operation of power. They move freely with the lateral motion of the piston rod and are entirely automatic in their action. Frequent machining of the piston rod is thus avoided. These packings are made in various forms and proportions and of metals which are best adapted to the conditions. The proper composition of these metals has been deduced from twenty years of experience and careful observation. The efficiency of Martell Packings does not depend on the application of force or the distortion of soft metal parts, since they are strictly mechanical products made on well-defined principles. They are made in many forms, two of the more common ones being illustrated on this page.

We will be glad to coöperate in the solution of packing problems on all classes of machinery.

HILLS-McCANNA COMPANY

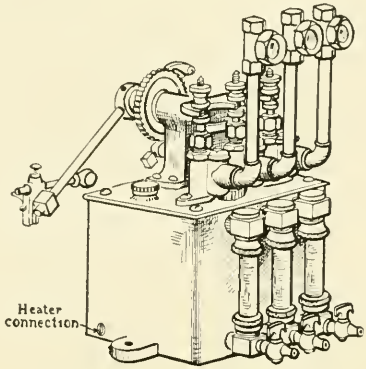
153 WEST KINZIE ST., CHICAGO, ILL.

STEAM SPECIALTIES; FORCE FEED LUBRICATING PUMPS; HIGH-PRESSURE GAGE COCKS; SWING JOINTS FOR BEARINGS; LOW WATER ALARMS; METALLIC DISCS FOR VALVES.



SINGLE OIL PUMP
With Glass Oil Holders

Made in 1 Pint and 1 Quart Size only



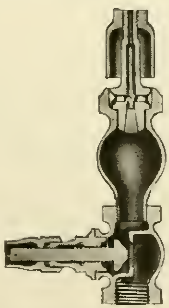
TRIPLE OIL PUMP
With Sight Feed and Metal Body

Made with any number of Feeds

Our oil pumps and other specialties have received the test of long use and varied applications. On our oil pumps there are no friction gears to stick; no belts to slip or break; no intricate parts to get out of order. The pump is operated by a positive action ratchet and the valves and operating motion are entirely outside the reservoir. A positive sight feed shows oil passing and the feeding of oil may be regulated to any degree without stopping the pump.

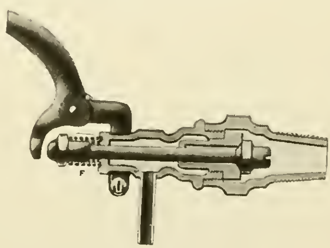
Heater connection may be made upon pumps for outdoor work.

LOW WATER ALARM
With Fusible Plug Combined



When the water gets low, the fusible plug melts and the whistle gives a loud clear sound.

SPECIAL GAGE COCK
For High Pressure



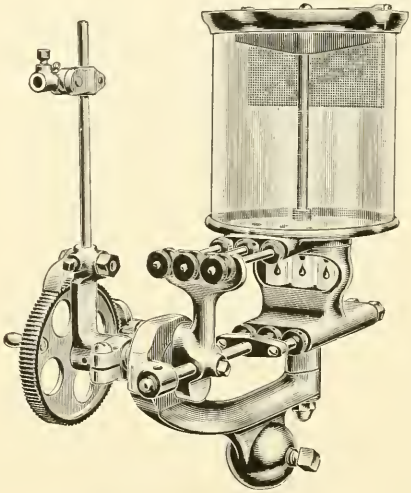
The stem, seat, lever and clamp, shank, body and spring are each renewable separately at trifling cost. Renewals are rare, as the construction is very serviceable.

MANZEL BROTHERS CO.

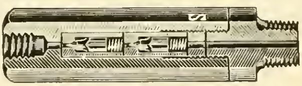
315-317-319 Babcock Street
BUFFALO, NEW YORK

MANUFACTURERS OF IMPROVED FORCE AND SIGHT FEED OIL PUMPS FOR CYLINDER LUBRICATION. ALL PUMPS ARE MADE RIGHT AND LEFT HAND SIZE FROM ONE PINT TO ONE GALLON.

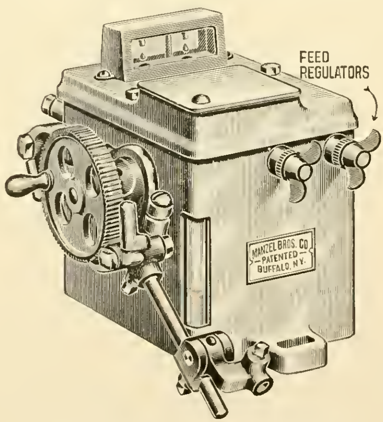
MANZEL OIL PUMPS



Class "B" Oiler—Triple Feed



Vacuum Check Valve
Furnished for each feed upon our pumps



Class "HA" Oiler—Double Feed

Manzel Pumps are guaranteed to give positive cylinder lubrication under all conditions regardless of steam pressure, temperature, speed of engine, or kind of oil used.

CLASS "B" OIL PUMP

This pump is of the double plunger type, the upper plunger forcing the oil out of the reservoir and through the sight glass—the lower plunger forcing it on through the check valve and into the steam cylinder, the amount of oil being adjusted on the upper plunger.

It has a constant sight feed and each feed is regulated independently. No liquid is used in the sight glass, nor is it under pressure.

The feed is easily and accurately regulated while the engine is running, by simply turning the regulating plunger.

Pump has a hand attachment for use before starting engine, or if more oil is needed momentarily while engine is running.

Sizes Made:—One Feed: $\frac{1}{2}$ Pt., 1 Pt., 1 Qt., 3 Pt., 5 Pt., 1 Gal. Two Feed: $\frac{1}{2}$ Pt., 1 Pt., 1 Qt., 3 Pt., 5 Pt., 1 Gal. Three Feed: 1 Qt., 3 Pt., 5 Pt., 1 Gal. Four Feed: 5 Pt., 1 Gal. Five Feed: 1 Gal. Six Feed: 1 Gal.

CLASS "HA" OIL PUMP

Our Class "HA" Oiler is designed similar to our Class "B" but has a metal reservoir with all of the working parts inside. It has a constant sight feed, hand attachment, accurate feed regulator, gage glass, etc.

Sizes Made: One Feed: 1 Pt., 1 Qt., 2 Qt., 3 Qt. Two Feed: 1 Qt., 2 Qt., 5 Qt., 1 Gal. Three Feed: 5 Pt., 3 Qt., 1 Gal. Four Feed: 3 Qt., 1 Gal. Five Feed: 1. Gal. Six Feed: 1 Gal.

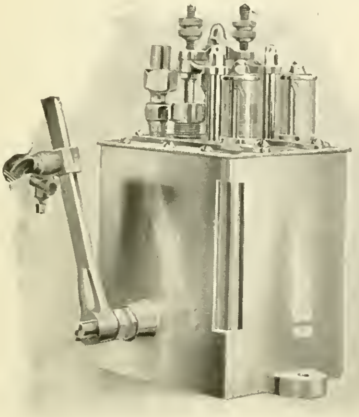
McCORD MANUFACTURING CO.

2587-2637 GRAND BOULEVARD EAST

DETROIT, MICHIGAN

McCORD FORCE FEED LUBRICATOR; THE McKIM GASKET; THE McCORD AUTOMOBILE RADIATOR.

THE McCORD FORCE FEED LUBRICATOR



An absolutely reliable and dependable lubricator. A great oil saver.

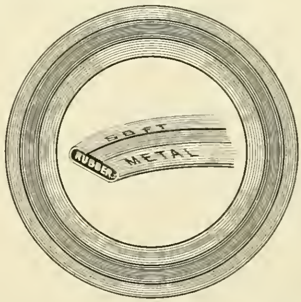
Built with any number of feeds and in several types adaptable to any engine or other machinery demanding positive lubrication.

Number	Oil Capacity	No. of Feeds
1	1 quart	1
2	1 "	2
3	½ gallon	1
4	½ "	2
5	½ "	3
6	1 "	1
7	1 "	2
8	1 "	3
9	1 "	4

THE McKIM GASKET—Copper-Rubber and Copper-Asbestos

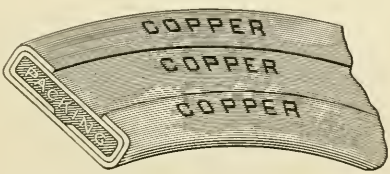
For years before rubber was obtainable, lead, copper and other ductile metals were used in various forms and alloys for use in gaskets. Being devoid of elasticity, however, their sphere of usefulness was limited and they were imperfect, besides being expensive. Since the introduction of rubber that material has been used but lacks strength for high pressures.

The McKim Gasket combines soft ductile metals with rubber and other elastic packings in a manner which produces a gasket capable of resisting heat, pressure and chemical action.



DOUBLE JACKET TYPE

For Extreme Pressure



SINGLE JACKET TYPE

For Ordinary Pressure

The solution of all leaky and troublesome joints.

Reduces tension on bolts and unions and minimizes repairs to broken fittings subject to undue strain.

Cost is low. Prices and sample sent on request.

THE RICHARDSON-PHENIX CO.

NEW YORK MILWAUKEE CHICAGO

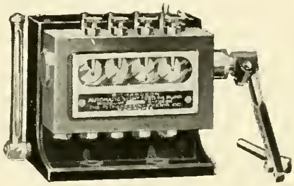
LARGEST EXCLUSIVE MANUFACTURERS OF OILING DEVICES
EVERYTHING FOR LUBRICATION BUT THE LUBRICANTS

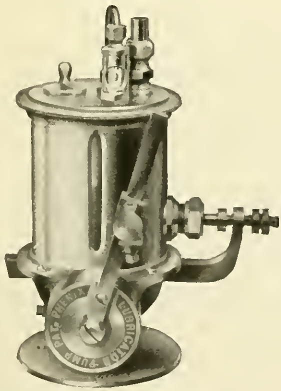
RICHARDSON-PHENIX APPLIANCES FOR LUBRICATION

include a complete system of automatic cylinder and bearing lubrication for steam and gas engines; pumps, air compressors, ice-machines and all power plant auxiliaries; steam hammers, dredges, saw mills, ore and stone crushers, etc.

RICHARDSON MODEL "M" LUBRICATOR

operates on a new principle in that it supplies oil in small particles for every stroke of the engine piston. Built in sizes of from one to twenty-two feeds and if desired can be furnished sub-divided to handle two or more kinds of oil. Fully illustrated and described in bulletin No. A-53.





PHENIX LUBRICATOR OIL PUMPS

are especially adapted to the lubrication of high-speed engines, all power plant auxiliaries, steam hammers, dredges, hoisting and traction engines, etc. Built in sizes from one to twelve feeds, square type, and one to two feeds, round type. Can be furnished with divided tanks if desired. Fully illustrated and described in bulletin A-54.

RICHARDSON AND PHENIX INDIVIDUAL OILING SYSTEMS

do away entirely with the necessity of installing overhead storage tanks, filters buried in the basement, or piping away from the machines; starts and stops with the engine or machine to which it is applied and the entire system is always in sight of the engineer.

Salient features—low first cost, simplicity, efficiency, reliability.

Can be applied to any size and type of engine or power plant auxiliaries from 5 to 5000 h.p. Fully illustrated and described in bulletin No. A-55.

ALBANY LUBRICATING CO.

ADAM COOK'S SONS, Props.

708-710 WASHINGTON STREET

NEW YORK, N. Y.

ALBANY GREASE AND ALBANY GREASE CUPS FOR THE LUBRICATION OF ALL KINDS OF MACHINERY, ESPECIALLY LUBRICATION WITH INFREQUENT ATTENTION. ALBANY GREASE HAS BEEN ON THE MARKET FORTY-THREE YEARS.

Albany Grease does not drip or waste, and it may be applied to a journal which is difficult of access and will lubricate efficiently for weeks or months without refilling or attention. This saves time of men and machines and lessens the risk of personal injury due to sending men into dangerous places to oil up. It also reduces fire risk, as Albany Grease will not kindle a fire; neither will it spatter upon clothes or goods nearby.

Albany Grease will feed perfectly through any grease cup and is made in seven regular numbers per list below. Their application and melting points are such that the user can select a number best adapted to his work under various conditions. Quality of all numbers is the same, the difference is only in consistency.

Packages of various sizes bear this registered trade-mark.

Soft Numbers

Albany Grease No. 0

A SOFT GREASE, used in extreme cold weather on exposed journals, or in rooms of low temperature; adapted for cable ways, gears, slides, chains, elevator ways, mining and quarrying machinery; also in transmissions and reverse gears of automobiles and motor boats.

Albany Grease No. 1

A MEDIUM GREASE, used in cold weather on ordinary journals and slow-running journals with heavy pressure; on elevator slides, mining machinery, and in the transmissions of automobiles and motor boats in summer weather.

Medium Numbers

Albany Grease No. 2

Commonly known as WINTER GREASE in most engine rooms; used in moderate and warm weather on general shafting, loose pulleys, friction clutches, crank pins, main bearings, etc.; on governors of engines, roller and ball bearings, mining machinery, ice machines; also on automobiles and motor boats in cold weather.

Albany Grease No. 3

Commonly known as SUMMER GREASE; universally adapted to all stationary, marine and tugboat engines, ice machines, shafting in warm weather or warm rooms, dynamos, general electrical and high-speed machinery, roller and ball bearings, motor boats, automobiles and bearings of gasoline engines, band saws, planer heads, traveling cranes, steam shovels, fans, blowers etc.

Hard Numbers

Albany Grease No. X

A HEAVY-BODIED, TOUGH GREASE for bearings that are heavily loaded, slightly out of line, or for one reason or other run unusually warm, also for main bearings of gasoline engines in motor boats where temperature is high.

Albany Grease No. XX

Has a higher melting point and will overcome lubricating difficulties beyond the reach of No. X.

Albany Grease No. XXX

Especially made for unusual conditions when temperatures surrounding the bearings are high, having a high melting point and great lubricating value; never fails in severe cases to overcome all lubricating difficulties.

THE TEXAS COMPANY

NEW YORK and HOUSTON

MANUFACTURERS OF LUBRICATING OILS, ENGINE AND MACHINE OILS AND GREASES. Lubricating Oils Prepared Specially for use with Turbines, Gravity-feed and Force-feed systems under all conditions.

Modern power plants and the plants of the future, consisting of steam turbines, steam engines or gas engines in large units, where the oil is used through circulating, gravity-feed or pressure systems, present a problem of lubrication which can successfully be met only by oils of the very highest class and lubricants which will withstand the unusually severe conditions under which they must operate.

The characteristics of an oil for this class of work must include ability to lubricate perfectly. The oil must separate immediately from any water which may get into it through leakages past stuffing boxes or leakages through the water-cooling appliances and must show as nearly as possible the same lubricating properties after thousands of hours as when new.

Another very essential feature is that the congealing point of the oil must be in the neighborhood of zero. This last point is especially important in large stations, where the oil is pumped from a central filtering plant to the engine, as there are many cases on record of shut-downs of the station in cold weather on account of the oil having congealed, thus making it impossible to pump it through the oil pipes to the engine bearings.

The Texas Company oils for the lubrication of turbines and for circulating systems contain features which give them a most decided value for such purposes. These oils are put out under three brands: TEXACO TURBINE OIL, for the lubrication of all steam turbines of every class and description; TEXACO CIRCULATION OIL, for use in gravity-feed and force-feed systems of all descriptions; TEXACO CIRCULATION OIL (Heavy), for use in force-feed and circulating systems on the largest engines, and especially for marine work.

Each of these three oils will separate immediately from water. They will retain their lubricating power indefinitely, will show a very slight change after thousands of hours and will in every way stand up to the most severe work.

The Texaco Oils for general rolling mill and manufacturing plant lubrication are of such a nature that great economy will result in their use. Every requirement of lubrication, whether from power economy, general plant economy, or cost, can be met by Texaco Lubricants.

INTERNATIONAL ACHESON GRAPHITE CO.

NIAGARA FALLS, N. Y.

OUR PRODUCTS INCLUDE ACHESON-GRAPHITE IN THE FORM OF ELECTRODES FOR ELECTROLYTIC AND ELECTROTHERMIC PROCESSES, POWDERED GRAPHITE FOR DRY BATTERY CELL FILLER, PAINT PIGMENT, POWDER GLAZING, LEAD PENCILS, FIREARMS LUBRICATION, ELECTROTYPERS' MOLDING AND POLISHING LEADS AND MANY OTHER PURPOSES.

We are the only Makers of Graphite in the world.

All Acheson-Graphite is made in the Electric Furnace, while all other graphite is mined from the earth.

By the process we operate, we produce, from particular forms of carbon, graphite of high purity, great uniformity and having certain definite chemical and physical properties. Our absolute control of the Electric Furnace operation and of all raw materials used enables us to impart to each grade of graphite we make the qualities essential to successful use.

No matter what your experience has been with natural graphite, it does not count with Acheson-Graphite. This is particularly true in the field of lubrication, as the guaranteed high purity of Electric Furnace Acheson-Graphite offered for lubrication assures superiority over Nature's product.

The two grades of Acheson-Graphite sold in powder form for lubrication are Grade "1340" and Grade "2301." Each is an unctuous, soft, practically pure graphite that possesses great spreading, covering and polishing power and is non-coalescing.

When applied to metal surfaces, in powder form where possible, or with grease or oil where a carrier is necessary, Acheson-Graphite fills in the irregularities, building up the hollows and burying the minute metal points until a high polish or veneer of graphite is imparted to the surface. Unlike a film of grease or oil, this film or veneer of graphite will not break down and permit the metals to seize or cut. Much of this great value is due to Acheson-Graphite not being flaky, crystalline, and hard, but soft and unctuous, so that under pressure the graphite moves within itself like a film of oil. In this way it reduces friction and prevents the parts wearing away. The fact that Acheson-Graphite is gritless is convincing that it will impart unusual smoothness to metal surfaces, affording a polish that will keep the bearings cool and eliminate hot bearings, which too frequently are the source of fires or costly shut-downs, tying up the output of a plant.

Ask for Booklet 417-T which tells more about Acheson-Graphite for Lubrication.

INTERNATIONAL ACHESON GRAPHITE CO.

NIAGARA FALLS, N. Y.

GREDAG

REG. U. S. PAT. OFF.

is the trade name selected by the International Acheson Graphite Company for its new Combination Lubricant of pure Acheson-Graphite and grease in order that it may be distinguished from the products which contain impure natural graphite.

ADVANTAGES OF GREDAG

GREDAG will withstand a very wide range in temperature changes, and it should be understood that a high temperature or a zero temperature will hardly alter its consistency, the fact being it does not change to any great extent between the freezing point and 135° F., so that in the average working temperature there is no change.

Plain grease melts and runs away, permitting the metals to seize and cut, while the graphite in Gredag imparts a graphite film that will not break under pressure, rendering it quite impossible for bearings so lubricated to seize and cut. The graphite we incorporate in Gredag forms the body of the lubricant, making it possible for us to employ a grease of very low viscosity as a carrier, thus effecting a valuable saving in power to those who use it, the fact being either grade of Gredag will serve a wider range of uses than plain grease lubricants.

Gredag is the only grease lubricant that contains unctuous, soft, pure, gritless Acheson-Graphite. It easily sets the standard for grease lubricants, as it has the following important advantages;

It is wholly free from the gritty impurities of natural graphite.

Owing to its high lubricating value, a softer grade of Gredag can be used than of other greases, thereby greatly lessening internal friction.

It will eliminate hot bearings.

It will reduce friction.

It will prevent wear of the parts.

It will effect a reduction in the quantity of lubricant necessary for best results.

The graphite in it has a Guaranteed Purity of at least 99 per cent and is therefore practically pure.

The Endurance and Efficiency of Gredag are such that its use will be found most economical.

Send for Folder 3S3 T. in which Gredag is more fully described.

Ask for a sample of Gredag, which we will gladly send.

ACHESON OILDAG COMPANY

PORT HURON, MICH.

MANUFACTURERS OF THE LUBRICANTS OILDAG AND AQUADAG.

WHAT OILDAG IS

OILDAG is a mixture of deflocculated unctuous Acheson-Graphite and mineral oil. Deflocculated graphite is reduced to a condition practically molecular, in which form it remains suspended in oil. An oil on examination may seem to possess all the qualities essential to successful results, but these qualities when in use become changed, destroying the lubricating qualities. It is not so to the same extent with Oildag, as the deflocculated graphite carried by the oil is in itself a true lubricant and does not evaporate, emulsify, oxidize or burn up as does oil.

As a lubricant for Automobiles, Commercial Vehicles, Motorboats, Motorcycles and other gas engine units, Oildag has been found to reduce the oil consumption more than 50 per cent. while it also increases the power by increasing the compression. It is put up in paste form for charging 1, 5, 10 or 50 gallons of oil.

WHAT AQUADAG IS

AQUADAG is a mixture of deflocculated Acheson-Graphite and water in which it remains suspended. As a lubricant it will not deteriorate under any of the conditions that change oil, while the viscosity of the heavier oils is eliminated, graphite imparting a body quite sufficient to lubricate journals and bearings sustaining a load, and capable of maintaining an extremely low co-efficient of friction. Engineers using a closed condensing system in connection with steam plants will readily see that Aquadag affords opportunity to lubricate their steam cylinders without the old and long-standing trouble of carrying oil into the boilers. Also it is useful in many situations where it is desirable to have a lubricant free from sodium sulphate, free alkali, sodium salts, or organic acids which many oils contain, any one or all of which may be injurious to metallic surfaces.

AQUADAG FOR METAL CUTTING

Gratifying results have been obtained in using Aquadag as an aid in all kinds of metal cutting such as screw-cutting, tapping, threading, etc. The higher specific heat of water, as compared with oil, results in a given quantity of Aquadag keeping the temperature lower and the tool cooler than will oil. Water has little or no viscosity, and will flow readily to the point of the tool during the cutting operation. The deflocculated graphite being in molecular form will enter the smallest opening, while it will not break down under pressure.

Folder Form 95 A describes these new scientific lubricants.

LIST OF CONDENSED CATALOGUES OF POWER PLANT EQUIPMENT

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